

Challenges of innovation as a strategy for generating land-based military capabilities

Desafíos de la innovación como estrategia para la generación de capacidades militares terrestres

Abstract: The generation of military capabilities is a permanent goal for the Armed Forces. In this attempt, innovation emerges as a promising strategy. However, there are challenges to be overcome for innovation to be an effective tool for generating superior and dynamic combat capabilities. This paper aims to identify the challenges for the effective adoption of innovation aimed at generating land-based military capabilities. In this regard, real examples of innovation and innovation management in the Armed Forces of different countries were addressed, allowing the verification of the main actions undertaken, mainly in the organizational, scientific, and technological fields. As a consequence, it was found that the *innovation theater* must be avoided, by implementing a culture and management of innovation based on objective and clear actions, aiming for tangible results, and considering a systemic approach that synchronizes the cycles of technological innovation, the life cycle of PRODE, and the factors that generate capabilities.

Keywords: Transformation. Life cycles. Military capabilities. Military innovation.

Resumen: La generación de capacidades militares es un objetivo permanente para las Fuerzas Armadas. En este intento, la innovación surge como una estrategia prometedora. Sin embargo, hay desafíos que superar para que la innovación sea una herramienta eficaz para generar capacidades de combate superiores y dinámicas. Este trabajo tiene como objetivo identificar los desafíos para la adopción efectiva de la innovación, con el objetivo de la generación de capacidades militares terrestres. En este mister se abordaron ejemplos reales de innovación y gestión de la innovación en Fuerzas Armadas de diferentes países, permitiendo la verificación de las principales acciones emprendidas, principalmente, en el ámbito organizativo, científico y tecnológico. Como consecuencia se verificó que hay que evitar el *innovation theater*, implementando una cultura y gestión de innovación plasmada en acciones objetivas y claras, buscando resultados tangibles y considerando un enfoque sistémico que sincronice los ciclos de la innovación tecnológica, la vida del PRODE y los factores generadores de capacidad.

Palabras-clave: Transformación. Ciclos de vida. Capacidades militares. Innovación militar.

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1 Introduction

1.1 Military innovation in the transformation of the Armed Forces

Just as the characteristics and conduct of military operations transform in space and time, the Armed Forces must adapt, modernize, or transform themselves to better perform their functions, both in times of peace and war (TEIXEIRA JUNIOR; GAMA NETO, 2018).

History shows that the most fertile periods for military innovation occur on the verge of the country becoming involved in conflicts of abnormal intensity (TELO, 2005). In times of peace, however, it is appropriate that the innovation process gains the status of an end-activity within the Armed Forces, promoting superior military capabilities and making combat power versatile, capable of stopping even unknown threats and in diverse environments. However, the Armed Forces need to adapt to the rapid changes in their environment, which is essentially made up of complex systems and products, influenced by technological advances, the demand for prompt responses, or the evolution of competitors. To adapt to different demands, dynamic capabilities are needed (TEECE; PISANO; SHUEN, 1997).

To achieve dynamic capabilities, it is necessary to develop a systemic vision of the products, processes, and systems that make up the organization itself. In the context of engineering and management, Systems Engineering is used, aiming at a broad understanding of current scenarios and the possibilities of adapting to future scenarios, through effective transformation or innovation (BRICK; SANCHES; GOMES, 2017).

Military innovation is characterized by the development or invention of new ways to fight, or to integrate technologies, materials, concepts, organizational structures, services, and systems (ANDRADE, 2011; ISAACSON, LANE, ARQUILLA, 1999), which result in the improvement of existing military capabilities or the acquisition of new ones and, consequently, the effective transformation of the Armed Forces in response to the Knowledge Age. Military innovation, therefore, encompasses all the factors that generate military capabilities — Doctrine, Organization, Training, Material, Leadership and Education, Personnel and Facilities (DOTMLPF) — and is not restricted to the scientific-technological domain.

Military innovation also exhibits strong dependence with the geopolitical context and national political-strategic drive (FERREIRA, 2015). In the 1970s and 1980s, Brazil began its insertion in the group of countries that can develop and manufacture their defense products (CUNHA; AMARANTE, 2011). However, these promoted innovations were practically annulled by the globalizing events of the following years.

Combined with the geopolitical context, the national culture can also make it difficult to implement a culture of innovation for better warfighting capabilities. The national culture presents some naiveties that should be avoided, such as the belief in the inexistence of threats and that the nation does not need to be prepared to defend itself; the thought that negotiations and the skills of diplomats and rulers are enough for the defense of the country; the belief that the Brazilian Armed Forces will be able to maintain combat with means ceded or acquired abroad;

and the assumption that an adequate Defense Industrial Base (Base Industrial de Defesa – BID) can be built even on a weakened national base (CUNHA; AMARANTE, 2011).

Dobni (2008) points out that in an organizational environment innovation is often expressed through behaviors and activities that are associated with a tangible action or result. It must be avoided that innovation is seen without commitment, as a simple metric of quality and success of organizations that aim to be innovative, investing in activities or resources considered innovative, without planning and implementing a culture of innovation. This behavior has been called *innovation theater*, through which organizations convey a superficial image, from unstructured initiatives, without continuity and without a mindset of transforming organizational culture (MJV Technology and Innovation, 2016, apud, Dutra e Almeida, 2018).

1.2 Objective

The importance and peculiarities of military innovation, compared to other innovation processes, reveal the need for constant investigation of the obstacles and challenges to be overcome, since the transformation of the Armed Forces and the art of war is a dynamic process that increasingly aggregates different aspects of all expressions of national power. In this context, the objective of this paper is to identify the challenges to effective innovation adoption, aiming at the generation of land military capabilities.

2 Theoretical background

2.1 Military innovation management in the Brazilian Army

Innovation has always been present in Armed Forces all over the world throughout Human History, both in the evolution of the art of war and in the technological progress of military employment materials. However, a systematic and institutional approach to the subject has grown in importance, which is related to the need for military insertion in the Knowledge Age.

The Brazilian Army established the guidelines for its transformation process through Ordinance No. 075-EME, June 10, 2010 (Portaria nº 075-EME, 10 de junho de 2010). This document points as objectives to "Promote the Army's transformation from an industrial to a knowledge era" and "Implement an innovation mindset", indicating the direction to be taken in order to "Enhance the ability to develop and incorporate advanced technologies in support of operational capabilities". In this way, this ordinance shows the relationship between military innovation, especially technological innovation, and the generation of military capabilities as tools to promote the Army's transformation from the industrial age to the Knowledge Age.

The first actions with relevant organizational impact, within the Land Force, regarding the management of technological innovation, occurred from 2015. In this year, the Agency for Management and Technological Innovation (Agência de Gestão e Inovação Tecnológica – AGITEC) was created through Ordinance No. 548 (Portaria nº 548, de 27 de maio de 2015). This agency began its activities as a military organization in 2018, having its purpose established by Executive Order No. 1,218 (Portaria nº 1.218, de 9 de agosto de 2019).

Art. 1 The Agency for Management and Technological Innovation (AGITEC), a support agency in science, technology and innovation directly subordinated to the Department of Science and Technology (Departamento de Ciência e Tecnologia – DCT), has the purpose of carrying out the Management of Technological Innovation, creating a favorable environment for the increase of scientific-technological capabilities and the development of new Defense Products (PRODE) and Defense Systems for the Land Force (BRASIL, 2019b, p. 30).

In this sense, AGITEC has been operating with emphasis on the finalistic processes of Technological Informations and Prospecting, Intellectual Property Management, Knowledge Management, and Promotion of Innovative Culture.

Additionally, the Army created, through Ordinance No. 1701, (Portaria nº 1.701, de 21 de dezembro de 2016), the Defense, Industry and Academy Innovation System (Sistema Defesa, Indústria e Academia de Inovação – SisDIA).

Art. 6 The Innovation SisDIA, based on the precepts of the Triple Helix, aims to enhance the efforts of the governmental, productive, and academic areas in order to, through technological innovation, contribute to national development, aiming at the search for Brazilian productive capacities of Defense and dual Products and Systems (BRASIL, 2016, p. 14).

SisDIA was recreated by Ordinance No. 893 (Portaria nº 893, de 19 de junho de 2019), establishing in its Art 1 the connection of the Army's transformation process with the generation of land military capabilities.

Art. 1 The Army Transformation process requires the adoption of measures that create, stimulate, and enhance national technological and productive capabilities, in such a way that these will endow the Land Force with operational capabilities compatible with the evolution of Brazil's political and strategic statures (BRASIL, 2019a, p. 36).

These actions of the Brazilian Army, whose main objective is the generation of superior and dynamic terrestrial military capabilities, use innovation as a strategy for this intent, assuming the Triple Helix and Open Innovation as pillars.

Thus, according to the Army Capabilities Catalog 2015-2035 the definition of land military capability is:

The land military capability consists of a group of operational capabilities with functional links, brought together so that their developments enhance the abilities of a force to accomplish a given task within an established mission (BRASIL, 2015a, p. 29).

Also presented in Brasil (2015) is the concept of operational capacity:

It is the aptitude required of a military force or organization so that they can achieve a strategic, operational, or tactical effect. It is obtained from a set of seven determining, interrelated, and inseparable factors: Doctrine, Organization (and/or processes), Training, Material, Leadership and Education, Personnel, and Facilities — which form the acronym DOTMLPF (BRASIL, 2015a, p. 29).

Therefore, we can see a link between the DOTMLPF factors and the generation of land-based military capabilities.

In the context of open innovation, connections and interactions are as important as the production and improvement of knowledge (TIDD; BESSANT, PAVIRR, 2005). Thus, it is understood that actions to identify promising ideas coming from the internal and external environment and to create effective mechanisms for the formation of partnerships aimed at obtaining technologies and PRODE, relevant to the generation of military capabilities, are paramount. However, it is essential that the collaboration with the outside world is done with the security of information sharing and protection of intellectual property, guaranteeing the national interests.

In addition, the change in the strategic environment and the limitations imposed on the defense and national public security budget, added to a very restrictive legislation, are factors that demand sustainable innovations in the business model. It is estimated, then, that the acronym DOTMLPF must be updated to DOTMLPF-RB, in which the restrictions (restrictions - R) and the business model (business model - B) are added to the universe of factors that generate military capabilities (FERREIRA, 2015).

3 Methodology

This work was based on a literature search, drawing on primary and secondary sources, collecting real examples of innovation and innovation management in different Armed Forces. The Google Scholar and Portal de Periódicos CAPES databases were consulted.

The present study will be restricted to military innovation, with a focus on ground forces, with some countries such as the United States, Germany, France, Israel, Russia, China and India being selected, which were chosen in view of their military relevance on the world stage. In other words, there was also a restriction as to the spectrum of countries investigated.

The research is classified as qualitative, since examples of management and innovation are investigated in terms of their qualitative aspects (NEVES; DOMINGUES, 2007).

Furthermore, the research developed can also be classified as exploratory, descriptive, and applied (NEVES, DOMINGUES, 2007, VERGARA, 2008). Thus, the exploratory feature is established by the literature review conducted that intends to identify examples of military innovation and military innovation management in Armed Forces in evidence in the global military landscape.

The research is descriptive because it seeks to make the object of study intelligible, that is, to identify examples of military innovations, describing their aspects, whether technological, organizational, or managerial, and their potential, especially with regard to the generation of military capabilities.

Furthermore, the research is applied, because it addresses issues present in the daily life of military institutions, providing subsidies for future studies and actions.

The theoretical framework addresses the current situation in military innovation, especially technological innovation in the Brazilian Army. In this way, the examples of innovation and management discussed in the research can be analyzed and adapted in such a way as to be implemented in the national context.

4 Challenges of military innovation

In military innovation, since it occurs in a strongly hierarchical, bureaucratized, and risk-averse environment related to doctrinal and technological changes, the *innovation theater* can be the tragic equilibrium point, where the necessary transformations do not occur and, consequently, superiority in combat conditions is not achieved, but it is believed that changes are being made within the Armed Forces in a gradual and controlled way. In summary, the *innovation theater* occurs when actions supposedly promoting innovation are implemented in a superficial way, without being inserted in the institutional innovation plan, without an established innovation strategy. In other words, the actions on screen are unstructured initiatives, lacking continuity and a mindset of transforming organizational culture (MJV *Technology and Innovation*, 2016). As a consequence, the desired innovation is not achieved, not generating the intended military capabilities.

Another trap to be avoided in the military lies in the origin of innovation. Innovation often does not follow the internal structure of the chain of command and requires less vertical relationships. Innovation can arise from relationships with the civilian environment, with government agencies, and with other Forces (GRISSOM, 2006). There is also the issue of innovation usually manifesting itself in two dimensions: *top-down* and *bottom-up* (DOUGHERTY, 2018). In the military environment, *top-down* innovation does not encounter resistance in its implementation, because it is in line with the hierarchical structure of the institutions and with the strategic planning of the Armed Forces. This is the case, for example, with the technological development or acquisition of new aircraft and new armaments. On the other hand, *bottom-up* innovation still needs to be better accepted in the organizational culture. This arises from the tacit knowledge of the combatant, the opportunity for improvement verified by the subordinate, or the need experienced by the human component directly linked to the tactical levels. It can be exemplified by

the U.S. *Marines' Army Expeditionary Warrior Experiment (AEWE)* — a *bottom-up* innovation hosting program, with processes designed to accept a prototype or concept from a non-traditional source to provide a military demonstration and a path to improved combat capabilities (DOUGHERTY, 2018).

Defense Products (PRODE), in general, are inserted in the context of technological innovation and have long life cycles. In addition, the PRODEs are often of a multidisciplinary nature, of sporadic demand, or needed in only a few units, and are often not attractive for production in partnership with civil industries, which require larger and permanent demands to make them viable. In other words, the model for obtaining PRODE faces the challenge of also considering a sustainable business model. The design of a new military capability must take into consideration the entire life cycle of a PRODE, as well as the determining, interrelated and inseparable factors for obtaining or maintaining the capabilities (DOTMLPF-RB) (FERREIRA, 2015).

The greatest difficulty in managing military innovation, therefore, results in integrating the innovation cycles of these factors with the technological innovation cycle, in accordance with the restrictions in the environment in which they are inserted. Its peculiarities such as uncertainties, gradualness, comprehensiveness to all the factors that generate military capability and, in general, the long term to materialize, added to the fact that it is inserted in a traditional and risk-averse environment (FERREIRA, 2015), make innovation management a very complex issue, but essential to the transformation of the Armed Forces during the Knowledge Era.

Chart 1 lists the challenges of military innovation presented in this section in summary form.

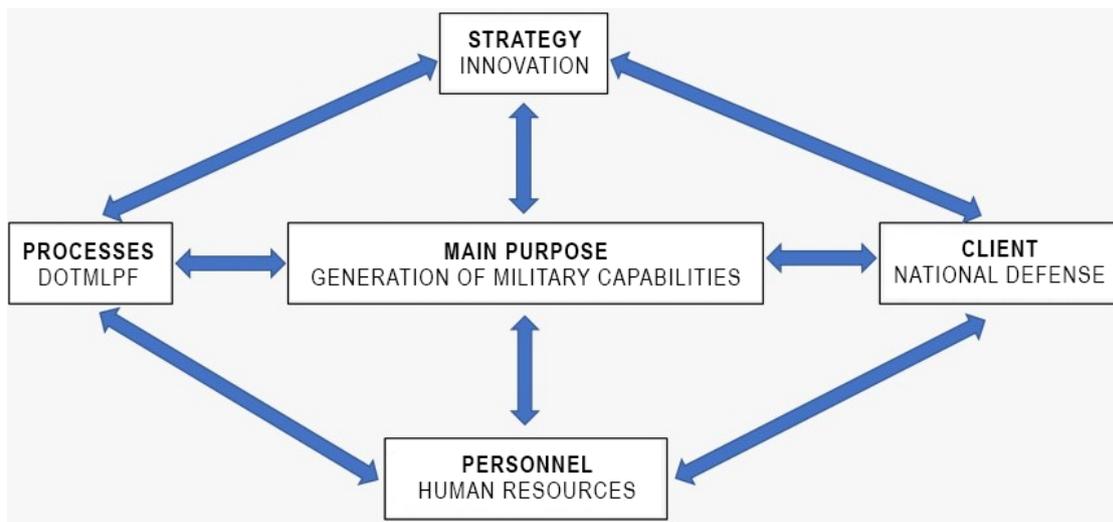
Chart 1 – Challenges of military innovation.

Challenges	Problem overview
<i>Innovation theater</i>	Lack of coordinated, integrated, systemic, and synchronized organizational planning and strategies for innovation.
Top-down hierarchy of the innovation process	Resistance or infeasibility of the bottom-up flow of ideas and innovations.
Excessive bureaucracy	Loss of focus on innovation by draining human, material, and financial resources to bureaucratic demands.
Aversion to risk	Low acceptance of mistakes, discouraging innovation.
Inter-institutional partnerships	Resistance to establishing inter-institutional partnerships for innovation.
Sustainable business model	Difficulties in establishing business profitable for all partners and with effective results for the end user.
Integrate the innovation and life cycles of PRODE with the factors advocated in DOTMLPF	Lack of integration between the innovation and life cycles of PRODE to the factors advocated in DOTMLPF.

Source: Authors.

Figure 1 intends to illustrate the relationship of innovation, as a strategy, to achieve the essential purpose of generating military capabilities, supported by the processes advocated in DOTMLPF, in order to serve National Defense. This figure is inspired by the strategic alignment model of Labovitz and Rosansky (1997 *apud* SENFF; COMPAGNONI; BENDLIN, 2014), which points to strategy, processes, customers, and people as elements that direct an organization to its essential purpose.

Figure 1 – Strategic alignment focused on generating military capabilities.



Source: Adapted from Labovitz and Rosansky (1997, *apud* SENFF; COMPAGNONI; BENDLIN, 2014).

5 Innovation and innovative management in transforming the nations armed forces – examples of implementation

In the search for elements to support a proposal for integrated and efficient military innovation management, capable of producing superior military capabilities, some examples of innovation management actions implemented in the Armed Forces of other nations were listed.

5.1 United States of America (USA)

Always seen as a benchmark that generates asymmetrical comparisons, the United States Armed Forces do not always show their supremacy based on their robust budget and technological exponents.

After the euphoria of the quick victory in Operation Desert Storm, the leaders of the U.S. Army knew that not everything had gone according to plan. There was also a sense that,

with the end of the Cold War and in light of the many combat experiences, they were entering an operating environment with an ambiguous threat that was difficult to predict, where the latest technologies were widely available (BELL, 2003). The U.S. Army needed a mechanism to quickly address the change of scenery. The response was achieved through innovations in doctrine, organizational structure, and training, with the creation of *Battle Labs*.

Battle Labs are integrated, brigade-level environments that are designed to facilitate observation of innovations in strategy, policy, resource application, doctrine, or methods of warfare (BELL, 2003). The proposal is to bring soldiers and tactical leaders from the Army and the acquisition corps into an integrated environment where innovations would be tested and evaluated right away, as in a laboratory, giving them the tools and resources to turn timely experiences and analysis into combat requirements.

The consolidated performance of the *Defense Advanced Research Projects Agency* (DARPA), which was created in 1958 as a Research and Development (R&D) agency, plays an important role in the U.S. Defense Culture of Innovation, and it is relevant to note the articulation with academia and business. DARPA is characterized by its autonomy and by being free from bureaucratic impediments, that is, without excessive bureaucracy, acting as an agency for the promotion and execution of innovation policy. DARPA supports innovative mission-oriented, high-risk, but high-reward research and promotes the development and deployment of these technologies, achieving true innovation. One of the innovation models adopted by DARPA is the *extended pipeline*, which consists of supporting all stages of the innovation cycle, starting from basic research to market creation with product acquisition (BONVILLIAN, 2018). The innovative technologies made possible by DARPA spread across many branches, such as space, aviation, internet, microelectronics, robotics, and nuclear, with tangible benefits for civil society.

5.2 Germany

Facing the constant economic crises of the beginning of the 21st century, Germany adopted new positions in the area of Defense, such as: the restructuring of its Ministry, centralizing activities, removing the Forces' commands from the central administration of the Ministry of Defense and seeking alignment with the strategic conception of the North Atlantic Treaty Organization (NATO); voluntary military service, as of 2012, replacing the mandatory one, which contributed to the budget, but created difficulties in obtaining the necessary manpower; and the rationalization of combat capabilities; and in relation to Military Employment Material (MEM), it is worth highlighting the reduction in the number of armored cars, artillery shells, helicopters and fighter planes (FERREIRA et al., 2016)

The binational integration with France and Holland, through the constitution of mixed brigades, fruit of the European Union integration project, is a relevant aspect. Terrorism is a matter for the Ministry of the Interior and has a strong political component.

Possibly, Germany's position on the terrorist threat should be expressed en bloc, confirming NATO's stance (FERREIRA et al., 2016).

5.3 France

The French Army is undergoing a transformation process, driven by three factors: the reality of new operations and threats, limited defense resources, and the already worn-out existing model. In this context, a new family of vehicles – *Scorpion* – is under development. Also noteworthy is the reactivation of the divisional level, which did not exist in the old structure, but without the structures corresponding to what we know as a Divisionary Base, providing a light and flexible Command structure. The transformation that has as its motto the term "*Au Contact*", making mention of the greater closeness to the population and the resumption of recruitment as a strategy to obtain skills and cultural assimilation. The ongoing process aims to structure the French Army for the next 40 years through innovations and more efficient management of the Institution (FERREIRA et al., 2016).

In France, the protocol for managing innovations within the Ministry of the Armed Forces – the Defense Innovation Roadmap – was presented last March by Florence Parly, Minister of Armies. This document summarizes the conclusions of the work of the "Innovation Task Force" – composed of representatives from the General Staff, government agencies, the Schools of Arms, the *Direction Générale de l'Armement* (DGA), and civilian industry – launched after the October 2017 Strategic Review. It is the development of an integrated approach by the Ministry to introduce the transformations enabled by external innovations, in which the main objectives are: harnessing the short technological cycles of the civilian world for the benefit of military capabilities; rapid maturation of new capabilities by prototyping; real-time synchronization of the short and long cycles of operational innovation (MELO, 2015).

5.4 Israel

Unlike countries like Brazil or the United States, in Israel, the Israeli Defense Forces – IDF – is known as an environment of little hierarchical intervention, where creative capacity and intelligence are constantly put to the test, being the core of the Israeli model of innovation. Attributes like this, added to the acceptance of error as part of the process, the scarcity of natural resources, and the risk of imminent attacks, create an environment highly conducive to innovation (SENOR; SINGER, 2011), even favoring disruptive innovation.

In the book "*Start-up Nation: The Story of Israel's Economic Miracle*", the authors, Singer and Senor, analyze what lies behind Israel's innovative profile and conclude that its underpinnings lie in strong investment in Research & Development – R&D (4.8% of GDP) and education (almost 11%), the role of the FDI, and immigration.

The Armed Forces play a central role in Israel's embryonic enterprises, through military R&D and various IDF *high-tech* units. In the IDF, Israelis, through compulsory service for

men and women, learn leadership and management techniques and develop proactive behavior for innovation and entrepreneurship. The Israeli Army has a strong impact on the culture of entrepreneurship in the country. On the one hand, the army reinforces focus and persistence in the execution of actions from start to finish, and on the other hand, it identifies the best heads through its special 8200 unit. In addition, the Israeli government proves to be instrumental in the development of the industry, acting in absorbing the risk involved and thus driving innovative attitudes (JUNQUEIRA, 2018).

5.5 Russia

Russia's military reform, which began in 2008, is part of a large-scale military emulation process that has the United States and North Atlantic Treaty Organization as the model to be emulated (DALL'AGNOL, 2019). The Russian Armed Forces suffered major deterioration in combat readiness, training, and equipment, evidenced in the performance of Russian troops in combat against the Georgian Army during the Russo-Georgian War (CHEVTCHENKO, 2016).

In earlier discussions attempts at reform already addressed both technological transformation and the shift from a division-based to a brigade-based organization. They focused on the technological progress of foreign militaries, especially the United States, in terms of redefining warfare in the information age (KIPP, 2010).

Since then, the Russian Ministry of Defense has focused on partnering with the civilian scientific sector and organizing international military-technical forums to find innovative ideas, technologies, and solutions to raise performance in innovation cycles and strengthen the country's military industry. The fruits of the Russian authorities' financial and administrative efforts can be seen in the 2016 results. That year, new equipment such as robots, unmanned aerial vehicles, hypersonic systems, nuclear-powered systems, command and control and other innovations were presented and tested in real combat conditions (DALL'AGNOL, SECCHI, 2018; SYSOEV, 2016).

The organization of the International technical-military Forums allows Russia to increase its power to protect its political and economic interests. The implementation of this plan has had good results. In the scientific-technological area, ten major Science and Research Institutes have been established to pursue the in-house development of sensitive technologies that are currently significant gaps in the Russian defense industry—such as microelectronics. In addition, potential buyers for their military-use products have emerged. It can be said that the sanctions imposed by the United States were part of the motivation for innovation in this regard (DALL'AGNOL, 2019; SYSOEV, 2016).

The Soviet practice of creating military departments in civilian universities, following the example of what the United States did and maintains, has been reclaimed and the Ministry of Defense still intends to create a branch of its Central Scientific Research Institute, composed of research centers dedicated to studying and improving the information and communication infrastructure management systems of Russia's Armed Forces, to implement network-centric warfare capabilities—the *New Look* (DALL'AGNOL, 2019).

5.6 China

According to World Bank data (SILVA, 2019), China represents the second largest Gross Domestic Product (GDP) on the planet, exceeding \$12 trillion, second only to the United States of America (USA), with its more than \$19 trillion. The country has been investing approximately 1.9% of its GDP in defense and, beginning with the 2015 reforms, appears to have embraced a commitment to develop top-tier armed forces by 2050 (SILVA, 2019). A country with a widely developed nuclear energy matrix since the 1960s and a permanent member of the United Nations Security Council since 1971, Beijing invested in a new phase of military modernization after the Fall of the Berlin Wall and after the technological performance obtained by the US in the First Gulf War (1990-1991). During Jiang Zemin's presidency (1993-2003), and in the face of episodes such as US pressure during the Taiwan Strait crisis in the mid-1990s, there was governmental effort to institute stricter controls over military organizations, to bring the Armed Forces closer to the Chinese Communist Party (CCP), as well as to address corruption and the privileges that military held within the regime (MALAFAIA, 2015). However, this picture followed with virtually no major changes under Hu Jintao, although stimuli were made toward modernizing the armed forces during the 2000s (PAGE, 2016). The Chinese government has invested heavily in new equipment, joint operations, and Information and Communications Technology (ICT). Major military projects include, for example, the development of different versions of aircraft with radar-stealth technologies based on the Chengdu J-20 (DOMINGUEZ; JOHNSON, 2018); the continued improvement of missiles, especially anti-satellite and anti-ship missiles, as part of what the Americans call the anti-access and area denial (A2/AD) strategy (MYERS, 2018); Aircraft ship investments (including plans involving the incorporation of nuclear propulsion) (YUSHA, 2018); and the high pace of domestic production of dozens of submarines and warships (YEO, 2018).

Thus, in addition to technological innovations, materialized in modern defense products, such as nuclear-powered submarines, combat aircraft, and naval means, the Chinese armed forces are also having their organizational structures renewed, replacing traditional bureaucratic comfort zones with joint commands, fostering new organizational cultures, reducing administrative staff, optimizing chains of command and control, extinguishing military units, reducing contingents, pooling common activities, and paving the way for greater civil-military integration, especially in the field of science and technology.

5.7 India

India has been adopting a Hybrid Model of military innovation, with priority given to Space Command and Battleship Aircraft in the Indian Ocean (NEVES

JÚNIOR, 2015). This Hybrid Model emerged as a result of the experiences of the Kargil War (1999), emphasizes technological modernization in space, air and naval means, combined with the structural maintenance of the country's Armed Forces and their fundamentally important social role in easing the rigidly caste-divided society.

Regarding the first aspect emphasized, its objective is to project force over the Indian Ocean, in order to deny its access to other Asian powers and to guarantee the so-called Vital Area, for the maintenance of its international communication lines and its economic expansion, and called Operational Area, where Advanced Defense would take place. In this way, we observe a geopolitical shift of India away from its historical interest: the land border with Pakistan (NEVES JÚNIOR, 2015).

The second aspect shows the limitations of the country, with delays arising from the history of rapprochement with the Union of Soviet Socialist Republics (USSR), budgetary difficulties, and the caste-divided society. Thus, many seek entry into the Armed Forces as a form of social ascension, besides these being a path for the increase of international relations that generate public-private partnerships for the development of the Defense Industrial Base and for technology transfer (NEVES JÚNIOR, 2015).

After the collapse of the USSR, India was driven to adopt a more integrated industrial policy, diversifying the Defense Industrial Base and strengthening domestic R&D, to achieve "self-sufficiency" in production of high-tech dual-use goods.

The biggest problem for the Indian government is to stimulate an entrepreneurial activity around the talent and technologies emerging from the defense industries. In India, although the *software* industry has benefited from dual-use technologies and *spin-offs* from the aerospace industry, there have been no clear policies to develop products for the civilian sector (SILVA, 2010).

6 Summary of the main innovation strategies adopted

Chart 2 reports the central ideas of the innovation strategies adopted by each of the countries listed in the previous item.

Chart 2 – Countries x Innovation Strategies adopted.

Country	Innovation Strategy	Key ideas
<i>USA</i>	Great investment in technological apparatus associated with innovations in doctrine, organizational structure, and training, with the creation of <i>Battle Labs</i> . Innovation culture built since 1958 with the creation of DARPA and free from excessive bureaucracy.	Synchronization of innovation cycles, reduction of bureaucracy, consolidated innovation culture, triple helix.
<i>Germany</i>	Renewal of its Defense Ministry, strategic alignment with NATO, and insertion in the European Union's integrated defense project.	International integration, organizational optimization, and rationalization of resources.

Country	Innovation Strategy	Key ideas
<i>France</i>	Transformation <i>Au Contact</i> , harnessing the short technology cycles of the civilian world to the benefit of military capabilities, and synchronizing innovation cycles.	Organizational optimization, rationalization of resources, open innovation, and synchronization of innovation cycles.
<i>Israel</i>	Innovation is rooted in the national culture and the role of the IDF in society, industry, R&D, and entrepreneurship.	Consolidated innovation culture and triple helix.
<i>Russia</i>	Military emulation of the U.S. and NATO models, creation of research institutes, organization of international military-technical forums, and maintenance of the national practice of inserting military departments in civilian universities.	Open innovation and strengthening the S&T base.
<i>China</i>	Technological and structural innovations, phasing out military units and reducing contingents, and greater civil-military integration, especially in S&T.	Rationalization of resources, reduction of bureaucracy, and triple helix.
<i>India</i>	Hybrid Model, focused on Space Command and Indian Ocean Battleship, establishment of public-private partnerships for the development of the Defense Industrial Base and for technology transfer.	Open innovation and triple helix.

Source: the authors

7 Conclusions

For the efficient implementation and management of innovation and, consequently, the generation of superior military capabilities, in the context of the transformation of the Brazilian Army in response to the Knowledge Era, different challenges must be overcome. In this sense, in order to meet the objective of this work, which is to identify the challenges for the effective adoption of innovation, aiming at the generation of land military capabilities, the following challenges are identified:

- a. avoid *innovation theater*;
- b. encourage and create mechanisms to exploit *bottom-up* innovations;
- c. combat excessive bureaucracy;
- d. accept and understand that mistakes and risks are present in the innovation process;
- e. encourage the establishment of inter-institutional partnerships, according to the principles of open innovation;
- f. develop sustainable business models; and
- g. implement a culture and management of innovation with a synchronous, systemic, and integrated vision of the innovation and life cycles of PRODE, using Systems Engineering, aiming at the generation of superior and dynamic military capabilities; and therefore, implement mechanisms of integration and development of the generating factors of military capabilities, observing the restrictions and the business model (DOTMLPF-RB).

Furthermore, based on the innovation strategies adopted by different countries and discussed in this paper, it is crucial to strengthen:

- a. the triple helix, aiming at scientific and technological development and innovation in partnership with universities, institutes, and research centers, observing the sustainability of the defense products and services business model;
- b. the agencies and structures for innovation management within the Armed Forces and the Ministry of Defense;
- c. the relationship of the Armed Forces and the Ministry of Defense with civilian Science, Technology, and Innovation promotion agencies, constantly keeping issues of interest to National Defense on the agenda;
- d. the acquisition models, observing intellectual property, knowledge management, and the sustainability of the business model;
- e. the incentives for research in technologies critical to the development of military capabilities;
- f. the qualification of human resources capable of absorbing and developing critical technologies; and
- g. optimize the organizational structures and the application of material, human and financial resources, prioritizing the most relevant projects for the development and maintenance of military capabilities.

Regarding the integration of technological innovation and military capability-generating factor innovation cycles, it is about developing mechanisms to generate superior land-based military capabilities for the benefit of the Army. These cycles should also be integrated with the life cycle of the PRODEs.

The life cycle of a PRODE, considering from conception to discarding, is a long-term life cycle, as, in general, is the cycle of technological innovation. Thus, one way to make the life cycle of a PRODE more compatible with the doctrinal and conceptual cycles is by phasing its evolution with partial deliveries of new technologies or intermediate products, through small projects, or sub-projects, that, successively, will converge to a complex product. Rapid prototyping and evaluation, as occurs in *battle labs*, is also of great value, avoiding rework and indicating the possibility of less demanding requirements.

To realize the integration between the cycles of technological innovation and that of innovation of military capability-generating factors, one approach is to choose to develop strategic technologies in a judicious manner, as a substitute for full product development. The choice of technologies to be developed can be guided through studies that point out which ones are priorities for obtaining the desired capability, or those that allow the development of a greater number of capabilities, such as artificial intelligence and compact energy sources (CALDEIRA, 2018), indispensable to the development of military mechatronic systems, which are already present in several complex products adopted by the Armed Forces and will be even more sophisticated, disruptive, and relevant in the Future War.

Therefore, from the above and revisiting the concepts established in the Army Capabilities Catalog 2015-2035 (BRASIL, 2015a), it is concluded that the generation of land military capabilities is achieved through the synchronous, systemic and efficient implementation of DOTMLPF, observing sustainable business models. In this way, innovation emerges as an effective strategy, acting in all factors that generate military capabilities: Doctrine, Organization, Training, Material, Leadership and Education, Personnel and Facilities. However, the challenges pointed out here must be faced, especially the innovation theater, which drains resources and discredits the efforts towards innovation, providing innocuous or unsuccessful results.

Finally, it can be seen that innovation is a fundamental strategy for the generation of dynamic and superior land military capabilities, contributing greatly to national scientific-technological and military development, and resulting in benefits for society as a whole.

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