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Analysis of the innovation value chain in strategic projects of the Brazilian Army

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innovation
value chain

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Abstract

Purpose – The purpose of this paper is to describe and compare seven case studies of strategic innovation projects of the Brazilian army; these projects present high transformational potential and high investments and are supported by technology and science policies.

Design/methodology/approach – The authors present herein multiple case studies in which the authors conduct a documentary analysis of the innovation processes in the Brazilian army, as well as semi-structured interviews conducted with eight servicemen with more than 15 years of working experience.

Findings – The results obtained suggest that the innovation process occurs in four stages: creation, selection, development and diffusion of ideas.

Practical implications – The research is relevant because it presents how the interaction between the Brazilian army, companies and academia strengthens the innovation ecosystem, stimulating the development of best practices for the management of strategic projects.

Originality/value – The main contribution of this study is to present the strategic project management of innovation based on public policies and investment in projects of the Brazilian army, which are drivers for the development of ecosystems that promote the creation and expansion of companies, the diffusion of technological knowledge in universities, and suitable solutions for the military sector.

Keywords Innovation process, Brazilian army, Defense sector, Innovation model

Paper type Research paper

1. Introduction

Even though innovation has been more and more present in entrepreneurial competitiveness, it also affects other sectors, e.g. civil defense. The military activity, known for its work intensity and troop ships, started to receive intensive capital and innovation investments from the half of the nineteenth century onwards (Markusen, 1986); there was, therefore, a shift from an weaponry competitiveness toward a scientific competition (Paarlberg, 2004; Schmidt, 2013). If during the Second World War the source of the military supremacy corresponded to the industrial production capacity of weaponry of countries like the USA (Paarlberg, 2004), by the end of the war, the scientific capacities started to focus on military powers (Schmidt, 2013), producing successive technology generations and quick changes in the strategic military environment.

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Regarding the sector of security and defense, the development and the institutionalization of formal system integration processes date back to the USA and the Cold War period, in which new well-structured innovation projects on technical and technologically complex themes were necessary to fulfill military goals. Due to these projects, weaponry systems became more numerous, aggregating other technologies and components, such as radars, nuclear weapons, rocket propulsion systems and electronic controls in systems that were more complex and ever harder to design, produce and operate (Davies & Hobday, 2005). In the Brazilian context, after the Second World War, the science and technology policies started to become more important. The government started to play an active role in the area of science and technology, guiding projects related to military equipment and other technologies through public intervention (Luz & Reis, 2010).

In the geopolitical and strategic global defense scenario, Brazilian servicemen adopted the strategy of focusing on internal qualification, industrial and technological capacities (Ravara, 2001), mastery of critical and sensitive technologies, organization of R&D and training of high-qualified human resources in a continuous way in order to enable the operation of new intensive and complex systems in the knowledge field (Leske, 2015).

Unlike the civil sector, products developed for the defense present as main characteristics the high lethality and high reliability to accomplish missions. Besides, these critical technologies experience trade barriers and legal restrictions in the countries that possess their property rights. These technologies present high development, production and logistics costs during their service life and reduced manufacturing scale of sophisticated systems and equipment. The production of these products has a high verticalization because the main components are, usually, developed and produced by the defense sector itself. With the development accomplished in long cycles, many times the production is subject to the demand with costs afforded by the costumer. Only simpler and regular consumption products, as for instance the small caliber ammunition, present a routine production and a more predictable commercialization, which is similar to the production of non-military consumer goods (Cunha & Amarante, 2011). In order to meet such demand, in 2008 the National Defense Strategy (NDS) was launched by the Federal President, in which it is possible to find more details about the science, technology and innovation policies for the national defense. The main purpose of such policy is to stimulate the science and technology development, as well as innovation, for the national defense through a national planning aimed at high-tech products. It also promotes the coordinated involvement of civil and military Science and Technology Institutions, industries and universities, defines priority areas and interest technology, and creates funding instruments for the research of materials, equipment and defense mechanisms (DOU, 2008).

With this, the Brazilian army developed strategic projects due to their importance, coverage and impact on all military systems. The crucial factors are centered around the areas: doctrine, resources (human and financial), technological innovation and management, whose main purpose is to meet strategic demands, such as the creation of a defense mentality in the Brazilian society and the use of defense products (Barcellos, 2014). The seven projects are Strategic Project ASTROS 2020, Cyber Defense Strategic Project, Anti-Aircraft Defense Strategic Project, PROTEGER Project, Guarani Project, Full Operational Capability Strategic Project (OCOP, in Portuguese) and Integrated System of Sensing Border (SISFRON, in Portuguese).

While previous research on R&D investments in the Brazilian defense sector focused on innovation policies (Leske, 2018) and impacts of innovation governance on the regional development of science parks (Silva & Quandt, 2019; Silva, Sá, & Spinoza, 2019), current research still does not present the phases of the innovation processes involved in the sector. In our study, we intend to evaluate the model of the innovation process – which is promoted by investment policies and present in industrial and academic ecosystems – through an applied research that aims to identify the common features among the projects.

In recent approaches on innovation projects, the role played by ecosystems for the success of these enterprises has been gaining strategic relevance, especially for enterprises involved in long-term and highly complex activities. Studies point out a need to carry out studies on the management of the innovation ecosystems regarding uncertainty, as well as their use regarding radical innovation, new markets and emerging industries, in which the value creation outweighs the value capture (De Vasconcelos Gomes, Facin, Salerno, & Ikenami, 2018), e.g. the strategic projects of the Brazilian army.

Our paper analyzes how the innovation process occurs during the management of strategic projects of the Brazilian army. In this context, the purpose of our research is to describe and compare seven case studies that present innovation projects characterized by high investments and transformation potential of the Brazilian army. We also intend to analyze how these processes strengthen the ecosystems, deal with uncertainties in the sector and promote the interaction among players in an environment that presents several restrictions and singularities.

2. Theoretical framework

2.1 Organizational innovation process

Organized in sets of activities related to idea creation, problem shooting, implementation and diffusion, the purpose of every innovation process is the generation of a significant economic impact (Salerno, de Vasconcelos Gomes, Silva, Bagno, & Freitas, 2015). In this process, not all ideas are used. Through an innovation funnel, ideas that are more likely to meet the market needs are selected to continue in the process until the implementation stage (Wheelwright & Clark, 1992). The purpose of the innovation funnel is to dismiss ideas in order to pursue a continuous reduction of uncertainties of a project or a set of projects (Silva, Bagno, & Salerno, 2014). In the first phase, also known as front-end phase, ideas are created and then screened according to their relevance; they are then analyzed in a second filter (Phase 2) in order to be approved and used in projects; at last, there is the introduction in the market in Phase 3 (Salerno *et al.*, 2015).

The collaboration between internal and external players in the innovation process according to Clark and Wheelwright (1992) is considered as a necessary technology and innovation source and for a wider selection of new ideas. Chesbrough (2003), on the other hand, proposed a structured open innovation model, as well as the acquisition of knowledge from external sources. According to Chesbrough (2003), open innovation is a way to obtain knowledge through the participation of the ecosystem players.

This model is in accordance with the ideas by Tidd, Bessant, and Pavitt (2001), in which resources from other external organizations reduce the costs of technological development, as well as market entry risks and the development time of a new product. In this model, it is possible to observe the collaboration from the external environment toward the company; and knowledge can also flow out of the organization toward external players through licensing, technology and spin-offs (Bueno & Balestrin, 2012).

Ideas created within the organization and ideas that stem from external partnerships, collaborations and interactions have to go through the procedures of selection, development and implementation before reaching the market as new products, services, processes, business models or a combination of two or more (Goffin & Mitchell, 2005).

Through this innovation ecosystem, the different players (bonded with the common purpose of ensuring value generation) can work both in a dependent way, as suppliers and purchasers, or in a more independent way, only for development and commercialization (Adner & Kapoor, 2010). The common focus of these players is co-innovation and the adoption of the necessary technology and innovation to implement new technologies effectively. This collaboration overcomes the traditional concept of value chain, in which it is possible to benefit from the intensive exchange of knowledge and adequacy to the environment in which the players operate (Lubik, Garnsey, Minshall, & Platts, 2013).

The benefits yielded to the economy through the innovation ecosystem through R&D investments of the military sector cover not only the creation of research and professional training centers, but also spin-off effects already in the initial phases of the research and valuable contracts established between the government and other companies that operate in the ecosystem (Mowery, 2010).

The analytical border, one of the characteristics of the innovation ecosystem, is not limited to national borders, regional clusters, contractual relations and/or complementary providers (Tsujimoto, Kajikawa, Tomita, & Matsumoto, 2018). This is an interesting aspect when analyzing innovation ecosystems in the defense sector because the business players are not the only ones covered; other non-commercial players, e.g. society, are also comprehended. According to innovation ecosystem literature, the players involved in the ecosystem and the leadership of other organizations are associated with a specific company (Nambisan & Baron, 2013); regarding the military sector, however, strategic projects are carried out by the Brazilian army.

Just like a collaborative network (Camarinha-Matos & Afsarmanesh, 2008), an innovation ecosystem is a long-term strategic collaborative network, guided by goals and aiming at specific business opportunities (Graça & Camarinha-Matos, 2017).

In the conceptual structure proposed by De Vasconcelos Gomes *et al.* (2018), the innovation ecosystem is characterized by the joint value creation accomplished by interconnected and interdependent players (focal companies, suppliers, complementary innovators and regulators). In the life cycle of the ecosystem, these players cooperate and compete among themselves in a co-evolution process, i.e. the reflex of the collaboration can be noticed in the evolution of the players from the expansion of the company to a greater participation in university and research centers.

A successful example of the interaction in ecosystems for the defense sector is Route 128 in Massachusetts, USA, which aggregates technological interests, high skilled human resources, infrastructure and the existence of venture capital in the region through the government, industries and academia (Massachusetts Institute of Technology and Harvard University) (Silva & Quandt, 2019).

Similarly, Almeida (2013) indicates that the form of action of Defense Advanced Research Projects Agency (DARPA in USA of America) shows how difficult it is to innovate without being inserted into an innovation ecosystem. The author gives the example of the close relationship between research centers, universities and private companies in the USA.

Regarding Canada, Nimmo (2013) presented the technological script of the initiative Soldier Systems Technology Roadmap, in which the role played by the government as a client seeks to engage industries, academia and other research organizations in order to modernize the Canadian army.

Among the innovation models, Goffin and Mitchell (2005) proposed a model with two extra elements, which totals five main areas or elements of innovation management. The Innovation Pentathlon Framework is composed of the elements: ideas, prioritization, implementation, innovation strategy and people and organization. The element innovation strategy is subject to the high management to develop and to fulfill strategic goals. The focus is a fundamental point in this phase, occurring through constant observation and monitoring of market trends and new technologies, with management being responsible for communicating the role of innovation within the company's areas. The element people and organization is related to people management and can occur through incentive policies, trainings and creation of an organizational structure that stimulates innovation (Goffin & Mitchell, 2005; Oke, 2007).

For multi-project organizations, Cooper (1993) indicates a model known as stage-gate. Such model understands that technological innovation is a process focused on the development of new products (Silva *et al.*, 2014). According to Cooper (1993), the development of new products

must be fragmented in predetermined stages; each of them consists of a list of prescribed, cross-functional and parallel activities, explaining the construction of knowledge, which is materialized in a good or a service through the other stages.

The stage-gate model is composed of five stages and five gates. The beginning of the process occurs with the emergence of an idea that is developed as it goes through specific evaluations throughout the process. The gates represent the decision whether to continue or to interrupt the project. The process occurs from Gate 1 (ideas are evaluated according to their feasibility in order to be forwarded to the R&D area with information about potentials and market entry) to Gate 5, where the global viability of the project is evaluated in terms of product, production process, consumer acceptance and economic issues.

In a structured high-performance innovation model (Jonash & Sommerlatte, 2001), the process innovation needs to be present in all value chains of the company; it cannot be restricted to R&D departments (Silva *et al.*, 2014). This model has two fundamental principles: to provide the entire company with innovation, creating value; and to boost technology and the competencies necessary to accelerate the sustainable innovation while providing competitive advantage. The first principle shows that significant innovations stem from an internal mobilization, involving the entire value chain. The second principle occurs through technology platforms and competence management. However, these activities are only possible if the company directs its efforts toward the five fundamental elements: processes, strategy, organization, resources and learning.

From the perspective of innovation value chain by Birkinshaw (2017), the process of idea creation is the first stage for a company to improve its outcomes regarding innovation. For this, the idea creation is separated in three phases: internal, interaction and external. The conversion is separated in two phases (selection and development), while diffusion presents only one phase (dissemination).

In the phase of idea creation, the environments internal, external and interaction between them are observed and a critical analysis is made regarding the importance of the emergence of new ideas, as well as the interaction among them, in order to be sustained outside company's borders. In the conversion phase, the ideas created are selected according to their importance and relevance, so that they can be implemented in products. The third and last phase – dissemination – approaches the propagation of the idea; the diffusion of the idea is established in percentages.

Another approach of the innovation process is based on empathy, inclusive thinking, experimentation, optimism and collaboration. This is the so-called design thinking a field that uses sensibility and designer methods to meet people's need based on what is technologically feasible; it is a viable business strategy that can be transformed into consumer value and market opportunity. Design thinking projects go through three stages: inspiration according to the circumstances (problem, opportunity or both) that enables finding solutions; ideation in the process of creating, developing and testing ideas; and implementation to design a roadmap toward the market (Brown, 2008; Geissdoerfer, Bocken, & Hultink, 2016).

A critical dimension for the innovation process is related to the organization and management, and the innovation perspective is central in the renovation process (Tidd *et al.*, 2001). In this context, the idea needs to emerge from an analysis not only regarding the environment (internal and external), but also from sensitive signs on threats and opportunities. This is the co-called search action. The next stage of the model is known as selection, which is responsible for deciding which signs must be taken into consideration. The third stage is implementation, i.e. responsible for translating the potential of the initial idea into something new and launch the product in an internal or external market. The fourth and last step described in the model is related to value capture, which is accomplished through the development of innovation – in terms of sustainable adoption – and diffusion – related to

learning and progression throughout the life cycle in order to enable the company to develop its own knowledge basis and improve the ways through which the process is managed.

We present in Table I the main models related to the innovation process described herein.

Based on the characteristics of the organizational models of innovation, we elaborated a conceptual model taking into account the approach of innovation value chain by Birkinshaw (2017), which contemplates the study variables and their relationships. The innovation

Model	Author	Characteristics	Dimension, process, phase
Technological innovation process	Utterback (1971)	Survival and expansion of the business competitiveness	Acknowledging the need Proposal Analysis, definition of goals and development Implementation
Innovation funnel	Clark and Wheelwright (1992)	Based on the principle of filtering ideas in order to select the best ones; such ideas are later translated into products that meet the market's needs	Idea creation Definition of the project and selection Implementation
Stage-gate	Cooper (1993)	It is necessary to understand that technological innovation is a process focused on the development of new products	Idea; preliminary investigation Business plan Development Testing, validation and production
Advanced and high-performance innovation model	Jonash and Sommerlatte (2001)	This model is based on two principles: systemic innovation, competencies and technology through platforms. It presents four dimensions, from which innovation emerges, and a fifth, related to the learning capacity	Innovation strategy Innovation process Innovation resources Organization of innovation Learning
Emerging routines to manage disruptive innovation	Tidd <i>et al.</i> , (2001)	Innovation is a generic process associated with survival and growth, composed of three phases. The effective innovation management assumes a good performance in four aspects	Innovation process: search, selection and implementation (permeated by learning) Strategy Organizational context Support Implementation mechanisms External relationship
Open innovation funnel	Chesbrough (2003)	To add value to the organization through multiple ways to see opportunities in the current or in new businesses	Gathering ideas is susceptible to inputs at any point: idea creation, internal development, acquisition of licenses, scale up products, etc.
Innovation value chain	Birkinshaw (2017)	Innovation as an integrated flow: from the creation of ideas toward the market entry. This approach enables the identification of challenges in the inactive process	Innovation process: idea creation, conversion and diffusion
Design thinking	Brown (2008)	Based on empathy, integrating thinking, experimentation, optimism and collaboration	Immersion (understanding and observation); ideation; prototyping; development
Pentathlon	Goffin and Mitchell (2005)	To boost the organizational innovation strategy	Creation of ideas; prioritization and selection; implementation; innovation strategy; people; organization

Table I.
Innovation
process models

Sources: Based on Silva *et al.* (2014) and Mazzola

process was divided into four stages: idea creation, selection of the best ideas, development and (adoption and) diffusion. Table II presents the conceptual model.

2.2 *Innovation and defense in the Brazilian army*

The technological evolution has been causing transformations in the armed forces, as well as in the defense sector, keeping track of changes in the innovation environment and its consequences in the sectors of telecommunication, energy, railways and aviation (Davies & Hobday, 2005). It occurs because contemporary wars depend on military strategies based on strategic and tactic advantages obtained through the intensive use of technology and knowledge (Martins-Mota, 2009).

At the first moment of the industrialization of the Brazilian defense – from the 1970s until the middle of the 1990s, with a peak during the 1980s – the sector was dominated by contracts with aviation companies (Embraer), armored vehicles (Engesa) and missiles (Aviras). This phase was characterized by technologies that met the local demands through innovation between multiple sectors and international cooperation in aeronautic and naval sectors (Amarante & Franko, 2017).

After the 1990s, the Brazilian defense industry was affected by a decrease and recession in the domestic market, which resulted in a significant reduction in defense production (Amarante & Franko, 2017). In 1999, the Ministry of Defense was created in order to establish a strategy for the sector; however, only one part of the budget (considered one of the highest among the ministries) was applied in investments related to development and innovation (M. Mazzucato & C. Penna, 2016).

Only in 2008, during the second phase, with the NDS (END, in Portuguese) the Brazilian defense industry restructured its guidelines along with innovation policies for the security

Stage	Characteristics
Idea creation	Internal and external cooperation (Clark & Wheelwright, 1992)
Idea selection	Ideas are the inputs to develop the rest of the process (Goffin & Mitchell, 2005)
	Initial screening; the best ideas are detailed and analyzed (Clark & Wheelwright, 1992)
	Concepts and projects can either be rejected or become the final innovative product (Goffin & Mitchell, 2005)
	Ideas that meet technical requirements and consumers' and market's needs
Development	Detailed investigation
	Evaluation of the importance and relevance of ideas (Hansen & Birkinshaw, 2007)
	Decision (taking into account how the company can improve itself) (Tidd & Bessant, 2015)
	Fast and efficient development of the new product, service or process or the combination of them (Goffin & Mitchell, 2005)
	Path from the emergence of the idea to the first result (Hansen & Birkinshaw, 2007)
Adoption and diffusion	Development of prototypes, tests and refinement (Brown, 2008)
	To translate a potential idea into something new, launching the product in an internal or external market (Tidd & Bessant, 2015)
	Pre-commercialization (Cooper, 1993)
	In the Brazilian army, the pre-commercialization is the pilot implementation in a determined area for practical tests carried out with the final user
	Production and launch in the market (Cooper, 1993)
Adoption and diffusion	After testing, there is a mass elaboration and distribution of products to places previously programmed to operate
	Disclosure in the entire organization (Hansen & Birkinshaw, 2007)
	After testing and during the implementation, the disclosure is accomplished through army channels and the media in general

Source: Authors

Table II.
Conceptual model of
the innovation process

of the country's borders focusing on natural resources of the then newly discovered pre-salt and gas reserves (M. Mazzucato & C. Penna, 2016). With the creation of END, investments enabled the development of industrial policies that boosted the development related to social and environmental aspects, while opening up to the competition to update the infrastructure (aircrafts, ships and vehicles), and establishing collaboration partnerships with national defense companies (Amarante & Franko, 2017).

These partnerships involved private technology companies, universities and research centers in three strategic sectors: aerospace, cybernetics and nuclear energy. The technology provided by these players are involved in several fields of the national industry like fighter jets, smart weaponry, submarines (nuclear and conventional), drones, communication technologies (M. Mazzucato & C. C. R. Penna, 2016) and health and agriculture solutions (Mowery, 2010).

These guidelines adopted by the Brazilian army, i.e. promoting the Brazilian defense industry through innovation, is in line with strategies developed by other countries, traditionally involved with the war industry, like the USA, Russia, France and England, and are similar to the ones developed by other emerging countries like India, China and South Africa (Leske, 2018). In the emerging economies, R&D expenditures on defense have a positive impact on innovation systems. Therefore, Brazil can learn some lessons from these emerging countries in order to analyze possible actions in the innovation ecosystem of the military sector: the high investment in R&D in India and South Africa; the positive impact of strategic and economic measures in the Chinese market; Russia's recovery strategy in a scenario very similar to the one presented by Brazil (Leske, 2015).

Currently, the land force develops seven strategic projects focused on innovation. Created and developed in the Office for Army Projects (EPEX, in Portuguese) located in the city of Brasilia, they are known as: Strategic Project ASTROS 2020, Cyber Defense Strategic Project, Anti-Aircraft Defense Strategic Project, PROTEGER Project, Guarani Project, Full Operational Capability Strategic Project (OCOP, in Portuguese) and Integrated System of Sensing Border (SISFRON, in Portuguese). The projects are described in Table III.

3. Methodology

Our research presents a qualitative approach and a multiple case study, whose focus is on the strategic projects of the Brazilian army. In the current study, we used a descriptive and exploratory approach to analyze the innovation process by means of primary data collection from interviews and secondary data from official documents.

Among the 824 projects developed by the Braço Forte Strategy (EBF, in Portuguese), we chose only seven because they present a high financial investment (from the 150bn reais invested in EBF, the seven projects demand an investment of approximately 90bn reais) and are transformational mechanisms in the army; i.e. they present a few transformation vectors: science and technology, doctrine, education and culture, engineering, management, logistics, budget and finances, training and employment and human resources. To choose these specific projects, we considered the importance, coverage and impact on every system; the lack of evaluation in terms of the common characteristics among them; the possibility to propose a systematization for future projects in order to enable the emergence of a more competitive and innovative model for the Brazilian army.

From all data collection sources suggested by Yin (2005), we used documentation, interview and direct observation. The data collection was accomplished through the conduction of semi-structured interviews in order to understand the role played by some leaders in the decision-making process.

In this context, we analyzed the army's official website, as well as the manuals and regulations in order to prepare the presentation of the research, the application of the interview model and the mapping of innovation processes. Then, we planned and carried out the semi-structured interviews.

Projects	Objectives	Participating companies	Academia	Estimate net worth (R\$bn)
ASTROS 2020	To provide means capable of bringing long-range shooting support with high precision and lethality to land forces	AVIBRAS (main development center), BRIDGESTONE, Elan, Alcoa, POLARIS, IMBEL, SIEMENS, AERO DIGITAL, DELL, ADVANTECH, Flight Technologies, Metrohm and Carrier	Military Institute of Engineering (IME) and Aeronautics Institute of Technology (ITA)	1.4
Cyber Defense	To train and develop protection measures and to mitigate cyber-attacks	APURA, RUSTCO, DÍGITRO, AVANTSEC, SOFTEC, ANSP, Itaipu Binacional, CENTRO DE TECNOLOGIA RENATO ARCHER, MODULO SOLUTIONS FOR GRC	Federal University of Campina Grande (UFCG), University of Brasília (UnB), Federal University of Minas Gerais (UFMG), Military Institute of Engineering (IME)	0.4
Anti-Aircraft Defense	To enable land forces to meet the defense needs of strategic land structures, protecting them from possible air space threats	KMW, BRADAR, SAVIS-EMBRAER DEFESA E SEGURANÇA, ATECH, RHEINMETALL DEFENCE, RFCOM, AVIBRAS, HARRIS, SAAB, Mercedes and Volkswagen	Military Institute of Engineering (IME)	4.1
PROTEGER	To protect strategic land structures to ensure social well-being	EXÉRCITO, MARINHA, AERONÁUTICA, RECEITA, ANAC, FORÇA NACIONAL, PRF and PF	Military Institute of Engineering (IME)	11.9
Guarani	To turn the infantry military organizations into modernized cavalry organizations	IVECO (main), CBC, EMGEPRON, CEMAÇO, HARRIS, USIMINAS, ALLTEC, HUTCHINSON, GEOCONTROL, EUROAR, AEL, OMNI and ARES	Military Institute of Engineering (IME)	17
OCOP	To provide the army with military equipment and defense products, which are necessary for the operational use	IVECO, IMBEL, MAN, HONDA, KMW, HARLEY-DAVIDSON, SPECTRA, FORD, Flight Technologies, AGRALE, Mercedes and Mectron	Military Institute of Engineering (IME)	30.1
SISFRON	This system provides remote sensing, decision-making support and operational use in order to strengthen the presence of the government along the border	SAVIS, BRASILSAT, AGRALE, KRYPTUS, ENECOL, RUSTCON, HARRIS, DIGITEL, ORBISAT, GIGACOM, VOLKSWAGEN, AEL SISTEMAS and ADVANTECH WIRELESS	Military Institute of Engineering (IME)	11.9

Source: Authors

Table III.
Strategic projects
focused on innovation

In the documentary analysis, the purpose was to understand the process of innovation in the Brazilian army; in other words, to understand the stages in which they occur, the responsibilities and the requirements demanded by the seven projects. We analyzed official documents obtained from the Military Institute of Engineering (IME, in Portuguese),

Brazilian Army Command and General Staff School (ECEME, in Portuguese), in journals, reports, official documents and lectures. When searching for these documents, we identified the stages of idea creation, selection of ideas, development and diffusion of innovation, according to the model in Table II. The documents located were publications of the official journal of the federal government (DOU, in Portuguese), 42 army reports, 10 ECEME journals, 10 lectures on innovation and defense, data from a symposium on innovation and investor relations reports provided by companies that took part in the projects. After gathering all information, we elaborated an integrated document in order to facilitate the access to the information.

In order to increase the reliability and validity of the research, we analyzed the answer of eight servicemen in different periods through a semi-structured and open questionnaire, and through observation methods (interviews and documentary analysis).

In order to evaluate the opinion of the servicemen regarding the innovation process in the Brazilian army, the interviews were conducted with servicemen that had working experience in the army and knowledge about the seven chosen projects. The criteria used to choose the interviewees were: working time in the army, knowledge about the projects, operation in the military sphere, participation in planning, development or implementation in the strategic and operational level in at least one of the projects. Before such criteria, we interviewed eight active servicemen: four of them were working in the army for more than 25 years; the remaining four, for more than 15 years. The purpose was to evaluate the innovation processes in the Brazilian army verifying possible gaps in future adequacy.

Table IV presents the open questions and the semi-structured interview.

We got in touch with them over the telephone in order to explain the purpose of the study and to introduce the researcher and the data collection process (organizational policy related to innovation management, methodological guiding, training programs and funding).

Open questions	<p>To what extent is the innovation process (technological and non-technological) of the defense sector integrated to strategic projects of the Brazilian army? Initially, four innovative projects were created (Guarani, SISFRON, DEFESA Anti-Aircraft Defense and OCOP). Based on Decree 134 (September 10, 2012), other three projects were incorporated (PROTEGER, ASTROS 2020, Cyber Defense and public-private partnership). What were these seven projects created for? Are these projects integrated? Is their purpose to develop an innovation system and a modern army?</p>
Semi-structured questions	<p>How does each one of the strategic projects help the innovation process of the army? How is the interaction among project agents? Which are the main barriers to the interaction of projects (armed forces, universities and industry)? How to overcome these barriers? Which are the main facilitators for project interaction? Which are the main interests of each agent when relating to other agents? What happens to the project when the interaction increases? Which are the main results or benefits expected from this interaction? How is it possible to motivate researchers to innovate? How supporting infrastructure does influence the search for partnerships when developing technological (and non-technological) innovation? How does the office establish a link among the innovations of a project in order to facilitate or benefit another project? Is there a collaboration among members of other forces in these projects? How do you think such interaction should occur? Which are the advantages and disadvantages of PPPs? Is there an interaction between projects and civil educational institutions? Which are the main improvements developed by EPEX in the processes that facilitated the project management?</p>

Table IV.
Open question and semi-structured interview

In order to carry out the interview with each participant, we used a semi-structured interview script (open interview). Each interview lasted between 1 h to 1 h and 30 min; they were conducted personally with five interviewees and per e-mail and telephone with the other three interviewees (two army generals and one colonel) and occurred in August 2016 (four interviews) and December 2016 (four interviews).

The data were analyzed based on the interpretation of the researcher and theoretical framework. The analysis categories were provided by the documentary analysis and bibliographic research.

We accomplished a discourse analysis in order to identify how the seven strategic army projects work and relate among themselves based on texts and interviews.

In order to carry out the analysis, we used the software Nvivo, which enabled the indexation of the texts stemming from the interviews, the insertion of the most relevant speeches before the variables of the conceptual model, as a basis for the analysis process and the integration between written material and speeches.

4. Analysis

According to the interviewees, there is an integration among projects as it is possible to identify common objectives and synergy, whose purpose is to develop an innovation system and a more modern army.

According to the conceptual model and methodological procedures presented herein, the results will be presented according to the order of the innovation process in the Brazilian army: idea creation, selection, development and diffusion.

4.1 Idea creation

In the army, the idea creation occurs according to the following actions (Servicemen 5–8): “(i) information obtained via exchange programs; that is, during interactions between Brazilian and foreign servicemen, and (ii) through operational reports (RIDOP, in Portuguese), a document that presents lessons learned during different military activities, sent from different headquarters to the Land Operation Command (COTer, in Portuguese), describing the main problems and needs of the army in a general way.” In the COTer, ideas are discussed to solve determined problems in the force. With this, ideas are sent to the high command of the army, then forwarded to the selection phase and, if approved, they turn into projects. According to every servicemen interviewed herein, the creation of the seven projects occurred due to the “need to provide the army with new capabilities, seeking for a progress that can be used in the entire force.” According to Servicemen 1–3, the strategic projects are responsible for providing the institution with new capabilities, which will enable the force to fulfill the planned transformation.

As result, it will be possible to meet the demands from the present and from the future with regard to the defense of the Brazilian territory: “the conception of transformation in the army is not just a modernization of already existing materials, but it is the acquisition of new capabilities that, in practice, means the achievement of innovation required by the land forces.” The idea creation in ASTROS 2020 came up from the need of the Brazilian army to provide means capable of providing long-range shooting with high precision and lethality to the land forces (EPEX, 2016).

Until the development of the Project ASTROS 2020, the Brazilian army had no surface-to-air missile. In this context, comparative analyses were carried out with solutions provided by other armed forces and with similar characteristics to the ones the Brazilian army needed in terms of long-range shooting; therefore, the project started being developed.

In the cybernetics defense, the development occurred due to the need to create an institution in charge of coordinating and integrating efforts to compose the defense.

In the Anti-Aircraft Defense, the idea creation occurred in order to provide the land forces with the capability to meet the demands for land strategic structures in the country, defending the territory from possible air space attacks.

With regard to PROTEGER, the idea creation came up in order to expand the capacity of the Brazilian army to coordinate operations regarding society protection.

The Guarani Project emerged from the interest of turning the infantry military organizations into modernized cavalry organizations (EPEX, 2016).

In the OCOPI Project, the idea creation came up to “provide the operational units with military materials” (Servicemen 5 and 7) in order to meet not only the requirements predicted by the defense of the territory (according to Article 142 of the Brazilian constitution), but also to the operations of Law and Order Guarantee and the several subsidiary missions attributed to the Ministry of defense. In order to fulfill this goal, 17 integrating projects were elaborated.

The creation of ideas for the Project SISFRON came from the need to “monitor borders” (Servicemen 1–4) in order to fight cross-border crimes, to bring social benefits to border communities and to increase the presence of the government along the border.

In every seven strategic projects, the creation of ideas occurred through a process known as cross-pollination (Birkinshaw, 2017); i.e. through the collaboration among units (military organizations). In this sense, the internal and external cooperation is necessary in this stage (Wheelwright & Clark, 1992); through such cooperation, it is possible to meet the technical requirements and consumer and market needs (Goffin & Mitchell, 2005). However, in addition to internal and external cooperation and taking into account that ideas are created from the inside out and vice versa, ideas can also be recycled (Wheelwright & Clark, 1992). This is the particular case of ASTROS 2020, in which the surface-to-air missile already existed, but had to be modernized and suited to the current technological scenario – shooting system and target control – and to the adjustment in the logistic process. Table V presents an overview of the idea creation stage.

4.2 Selection

In this stage, only the best ideas are chosen (Clark & Wheelwright, 1992) for the development of new products, processes and services, i.e. important and relevant ideas (Birkinshaw, 2017). Regarding the seven projects, the ideas “were selected by the military high command and forwarded to EPEX, which improves and develops them in order to meet the demands required by the force” (Servicemen 5). The best ideas are the ones technically viable, financially feasible and that meet the operational needs of the Brazilian army.

According to Servicemen 1–3: “all projects have one manager and one supervisor, who are responsible for leading the management team. The manager and the supervisor are either army generals or colonels with professional maturity.” According to the statement by Serviceman 5, the three criteria adopted to select the best ideas are: “finances” – subject to the finances board, responsible for the financial analysis, resource availability, investment possibilities and costs; “operational needs” – represented by COTER, the institution responsible for the operational area of the force, identifying operational needs and categorizing priorities; and “technology” – subject to the board of science, technology and innovation (DCTI, in Portuguese). The purpose is to verify the feasibility of the projects according to the current technology and establish cost valuation. The insertion of the three spheres represents the best ideas that will consequently turn into projects, meeting the needs of the force. Table VI indicates the guidelines for idea selection.

4.3 Development

The projects are an answer to the attributions of the army demanded by the documents that regulate the defense of the Brazilian territory. Once this legal landmark – external to the

Project	Need	Creation of ideas
ASTROS 2020	To provide means capable of bringing long-range shooting support with high precision and lethality to land forces	Several technologies used around the world, and understanding the demands made by the force
Cyber Defense	To ensure the defense (safeguard) of online digital means (cybernetic), governmental or not	It emerged from the idea to develop a protection system to store data on the Brazilian army and institutional websites, especially for the World Cup and the Olympics
Anti-Aircraft Defense	To provide the land force with the capacity to meet the defense demands of the land strategic structures of the country	Stemming from the adjustment of anti-aircraft artillery units
PROTEGER	To increase the capacity of the Brazilian army to coordinate operations to protect the society	Stemming from society protection ideas, as well as strategic structures, considering the increasing need for protection
Guarani	To turn the infantry military organizations into modernized cavalry organizations	It emerged from the idea to promote greater mobility, armored protection and shooting power
OCOP	To provide operational units with military equipment	It emerged from the idea to adjust the weaponry and equipment used by the Brazilian army; i.e. to modernize the Brazilian army according to current needs
SISFRON	To monitor 22,000 km borders	It emerged from the idea to improve the control of accessing the Brazilian border

Common features of the projects

Ideas created through information obtained from exchange programs and informational reports (RIDOP)
 The ideation of the seven projects occurred due to the need to provide the army with new capabilities, looking for improvements that could be used in the entire force
 The transformation conception of the army does not refer only to the modernization of existing materials, but to the development of new capabilities, which indicates the accomplishment of the innovation required

Table V.
Creation of ideas in the Brazilian army

Projects	Purpose to select the idea
ASTROS 2020	To increase the artillery capacity by providing extended range, flexibility and lethality (Serviceman 2)
Cyber Defense	To protect the cyber environment (Serviceman 4)
Anti-Aircraft Defense	To suppress possible air threats in the world scenario
PROTEGER	Selection of the best ideas and products that operate in cities affected by natural disasters; to protect more than 600 strategic structures; to provide support in cases of public calamity; and to create regional operation centers (Serviceman 8)
Guarani	To increase the mobility of infantry military organizations (Serviceman 6)
OCOP	To obtain the necessary material – defense products – to fulfill the force's land operation (Serviceman 7)
SISFRON	To monitor borders ensuring the continuous and safe flow of the land force (Servicemen 1–4)
All Projects	The ideas are selected by the high command and forwarded to EPEx, which improves these ideas and enables their development
Opinion of the servicemen interviewed herein	All projects are strategic: one manager and one supervisor – army generals and/or colonels with professional maturity – lead a management team The best ideas are the ones technically viable, financially feasible, and that meet the operational needs of the Brazilian army The selection of ideas is based on: finances; operational needs; and technology. The intersection among these spheres represents the best ideas, which will consequently become projects

Table VI.
Idea selection in the Brazilian army

force – is approved, the army develops strategic projects, whose scope is presented to government institutions that interfere with the execution regarding resources, such as the Ministry of Defense, the Ministry of Planning, the National Treasury Secretariat, among others.

“The main challenge, in executing large projects, is the lack of regularity of budgetary resources” (Serviceman 2); i.e. the lack of long-term planning, which affects the development stage directly. One of the ways to facilitate the planning and improve the continuous flow is the establishment of public–private partnerships (PPP). However, “even though there are significant advantages and several successful cases abroad, Brazil has no consolidated experience regarding PPPs.” There is “a need to clarify some legal issues in order to enable initiatives with legal security because, usually, these are long-term initiatives” (Serviceman 1).

The development stage, despite coordinated by EPEX, occurs in a decentralized way. In this sense, every project has a reference center that is responsible for its development, not only during the technical, but also during the testing phase. In the case studied herein, each project is developed in a center that can establish a PPP. One example of an activity used during the development phase is the establishment of prototypes, which enables the manufacturing of products that will be tested jointly in pilot projects. “The place where they will be tested is always planned, as well as the materials to be tested” (Serviceman 5). Table VII presents an overview about the stages that constitute the innovation value chain of strategic projects.

4.4 Diffusion

It occurs through the implementation of projects in determined places; their effects are tested *in loco*. This way, it is possible to identify possible flaws and to make all necessary adjustments. After the adaptation of the projects to meet the needs of the Brazilian army, they are implemented in military organizations to be used and evaluated one more time. When necessary, new adjustments are accomplished. Only after calibrating all adjustments, it is possible to choose the regions where new tests will be carried out; however, not only with one military organization, but involving other organizations. This way, it is possible to identify if the projects are fully integrated to the operations and if they meet the requirements to which they were developed, generating the necessary systemic capabilities.

Servicemen 1–3 mentioned that some of these products were “(i) the Saber Radar M60 (Anti-Aircraft strategic project), designed to monitor the air space and already present in the Anti-Aircraft artillery of the army; (ii) Saber Radar M20 (ground surveillance), acquired and distributed to border units; and (iii) Guarani, used during the 2014 FIFA World Cup and 2016 FIFA Confederations Cup.”

The adoption of implemented projects and products occurred in two steps. Initially, part of the project and/or material was analyzed and tested. After testing, the safety and basic functionality were verified. After this, a region is chosen and a group of servicemen test the product during a determined period in real circumstances, i.e. the functioning of the product in practice. After the accomplishment of several tests in real situations, there is a new evaluation and verification of strengths and improvement areas. Reports are analyzed and products and processes go through adjustments; they are then distributed.

The projects implemented so far improved significantly the mobility of the troop and armored protection, increased the shooting capacity, promoted more security by means of communication (digital, radio frequency and telephony), improved the border protection (ground and air space), besides increasing the modularization capacity and the protection of critical structures.

Regarding the challenges found, it is hard to keep up with the schedule due to the delay of financial support; i.e. due to the slowness to release funds. The long-term and high-tech projects adapt to new technologies and to the development of new techniques that help adjusting the projects to the Brazilian reality. Table VIII shows an overview of the diffusion stage.

Projects	Characteristics of the development
ASTROS 2020	Main development center of the company AVIBRAS; more than 60 companies are involved in the process. The project presents high skilled labor force, intensive knowledge on missile navigation, a 300 km missile reach and exports potential. Besides, it was responsible for the generation of 7,700 job positions (Serviceman 3)
Cyber Defense	There is not one main company; however, there are 25 companies taking part in the project. The purpose is to provide network safety and training for the cyber field (Serviceman 4). Through technology, it was possible to neutralize around 756 attacks during the 2014 FIFA World Cup
Anti-Aircraft Defense	There is no main company, but several companies involved in the development. The development of radar and command and control technologies ensures the protection of strategic structures (Serviceman 5). The reach of M60 and M200 are 60 km and 200 km, respectively. The project enabled the generation of 2,300 job positions
PROTEGER	There are 20 agents involved in the development. The main purposes of this project are to provide support in cases of natural disasters, public calamity and protection in land strategic structures (Serviceman 8)
Guarani	IVECO is the main company, but there are other 50 companies also involved in the project. It was possible to create 2,890 job positions; at least 60 armored vehicles were manufactured annually. It presents a high exports potential and the purpose is to strengthen the national defense industry, as well as the mechanization of infantry brigade and cavalry brigade (Serviceman 6)
OCOP	It relies on 30 companies involved in the development. In this project, 3,150 IA2 IMBEL rifles, 6,500 vehicles and 26 naval vessels were acquired. The purpose of this project is to modernize several materials, revitalize armored vehicles and helicopters and the acquisition of defense products (Serviceman 7)
SISFRON	Accomplished through the joint venture TEPRO, which included the selection of the main suppliers of electromagnetic sensors, tactical communication, optronics and infrastructure. In total, 12,200 job positions were created, and its purpose is to fight border crime, to bring social benefits to border communities and to promote the presence of the government along the border (Serviceman 3)
All Projects	Development phase of army projects: coordinated by EPEX and in a decentralized way Use of reference centers responsible for developing the projects during the testing and technical phases Possibility to establish public-private partnerships Main challenge: to get budgetary resources for a long-term planning

Table VII.
Development in the
Brazilian army

5. Conclusion: implications and future research

Our study described the innovation process in the Brazilian army with four stages outlined in the conceptual model: idea creation, selection of the best ideas, development and adoption and diffusion. In order to meet the research goal, a qualitative study was carried out, focusing on seven strategic projects not only because they intend to change the land forces by modernizing and equipping it, but because they are focused on relevant issues, i.e. the protection of society, maintenance of law and order and defense of the country.

After the emergence of the NDS (END, in Portuguese) and the National Defense Policy (PND, in Portuguese), issues related to the promotion of scientific research, technological development, the production capacity of materials and services relevant in the defense sector, the intensification of the exchange between the armed forces and universities, research centers, industries and partnerships with other countries, started to be considered relevant and became more and more frequent (ABDI, 2013).

In this sense, it is worth pointing out that the seven strategic projects are in line with the triple helix model (Juarez, 2016), in which the participation of players of the public, academic and industrial spheres is necessary in order to overcome a social relevant challenge through technology. The prominence of the university is related not only to training and research

Projects	Characteristics of the diffusion
ASTROS 2020	AVIBRAS – US\$ 350m contract established with the Indonesian government in order to develop 36 Astros 2020 missile platforms in exchange for technology and defense cooperation
Cyber Defense	To block hacker attacks in official websites
Anti-Aircraft Defense	RADAR SABER M60 – developed to monitor air space; it is already present in the army's anti-aircraft artillery. RADAR SABER M20 – land surveillance; acquired and distributed across border units
PROTEGER	The Cavalry Guard's Second Regiment accomplished an operation in the city of Seropédica, Rio de Janeiro. The operation consisted of the establishment of a control station to ensure security and access control to sensitive areas, in order to protect the area during major events, like the Olympics and the 2016 Summer Paralympics
Guarani	Used during the 2014 FIFA World Cup and 2016 FIFA Confederations Cup
OCOP	All operational military organizations of the Brazilian army received new vehicles. Example: 10-ton 6x6 trucks, served as a prime mover towing the 155-mm gun
SISFRON	The modernization of the vehicles involve the acquisition of non-armored cars and the recovery of armored vehicles, and the use of weaponry and vessels. Example: 5.56-mm IMBEL A2 (IA2) rifles; the first 1,500 batch was acquired in 2013
All Projects	In 2014, the first SISFRON unit was activated in the state of Mato Grosso do Sul (city of Dourados) to strengthen the presence and action capacity of the government along the border, besides helping policemen to fight illicit acts, like drug and weapons trade, smuggling and also health protection
	The diffusion in the army occurs through the implementation of projects in determined pilot areas in order test the produced effects <i>in loco</i>
	There is an identification of possible flaws and the necessary adjustments are accomplished. After the adjustments of the projects to the needs of the Brazilian army, they are implemented in military organizations to be used and evaluated one more time

Table VIII.
Diffusion in the
Brazilian army

characteristics, but also to the academic entrepreneurship, which enables the economic use of the knowledge produced. The industry, in order to ensure competitive advantage, has to be open to external sources of innovation. The government has to support and facilitate the synergy between universities and industries. In order to meet the requirements of the triple helix, the establishment of public policies in line with the defense sector is also necessary (M. Mazzucato & C. C. R. Penna, 2016).

This way, the results indicate that, just like in countries with a broader tradition in the defense sector like the USA, the development of innovation in defense areas presents a cooperative behavior in global innovation chains in order to distribute costs and acquire technology (Amarante & Franko, 2017).

The findings of our study indicate the possibility of technology spillover; that is, the use of technology for civil players in the innovation ecosystem and for global use, which is observed in the weaponry industry of the USA (Leske, 2013) and in Brazilian unmanned aerial vehicles, radar systems and satellites commercialized in international markets (COMDEFESA, 2011).

Based on the results presented herein, we consider that the innovation process in the Brazilian army occurs in a gradual way in order to fulfill all constitutional obligations and the END guidelines, besides showing that the efforts used to develop the seven projects culminate in a modern and well-prepared army.

The characteristics found in each project in each one of the stages are different. Such difference is observed, for instance, in the stages of idea creation and selection, in which each project presents differences in terms of use and manufacturing. Despite different, they are, however, compatible (e.g. the development stage) because they aim at the participation of companies and universities, and promote the implementation of the project in order to meet the demands of the force and possible exports of the product (diffusion).

Due to differences found in the stages of creation and selection of ideas, which is a consequence of the different technologies inside the ecosystem, it is hard to predict relevant business aspects; that is, to deal with collective uncertainties (De Vasconcelos Gomes *et al.*, 2018), like the management of resources and long-term planning, which is shown in Table VIII. These results indicate a need for management models adequate to the different complexities of the projects, and that can deal with the uncertainties that affect the performance of the players of the ecosystem.

The results contribute to literature on innovation project management by emphasizing the importance of the establishment of an interaction mechanism and the creation of ecosystems. In other words, the closer and the more collaborative the relationship among players, the higher the possibility to create innovation ecosystems that promote the evolution of the agents involved and innovation diffusion. In the cases analyzed herein, some companies were created, e.g. IVECO and AVIBRAS, to operate in strategic projects; they evolved from the innovation development and are known as a world reference in determined knowledge areas and production of equipment.

The projects of the companies inserted in the ecosystems involved automobile manufacturers and military equipment integrators, besides equipment, services and distribution suppliers. The predictability of the demand, one of the biggest problems and risks for companies operating in this sector, was mitigated by means of the financial amounts applied direct and indirectly, which provided the companies with financial stability and conditions to enter the external market. The more involved in the ecosystems of military project ecosystems supported by investments, the greater the management of strategic projects. The greater the market stability, the greater the participation in the ecosystem.

This study corroborates the public and private management when presenting the advantages of participating in ecosystems of strategic innovation project management in the public sector. With the establishment of public policies that promote innovation, the ecosystems involving public sectors (like the Brazilian army, public companies and universities) will indicate new markets for companies to enter and expand, development of technological knowledge to universities and establishment of adequate solutions to meet the needs of the army.

Based on the results obtained herein, we recommend the conduction of quantitative research in future studies to investigate other issues: the fulfillment of project goals; the influence of the schedule on the innovation process when it is centralized in only one company and when it is developed by several companies; the identification of positive and negative impacts that political and economic changes can have on the project; the confirmation that the seven projects sufficient to bring the desired modernization to the Brazilian army. The analysis of these other variables will emphasize the innovation process of the Brazilian army, meeting the goals proposed by the force and ensuring the country's protection.

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Further reading

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