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THE INFLUENCE OF A CULTURE OF INNOVATION ON THE DEVELOPMENT OF SOFTWARE-DEFINED RADIO FOR THE DEFENCE SECTOR

A INFLUÊNCIA DA CULTURA DE INOVAÇÃO NO DESENVOLVIMENTO DO RÁDIO DEFINIDO POR SOFTWARE PARA O SETOR DE DEFESA

Gabriela Alves de Borba
PhD student in Military Sciences
Brazilian Army Command and General Staff School,
Rio de Janeiro, Brazil
gabriela.alves.borba1@hotmail.com

Carlos Eduardo Franco Azevedo
PhD in Military Sciences
Colonel in the Brazilian Army
Brazilian Army Command and General Staff School
Rio de Janeiro, Brazil
francoazevedo@francoazevedo.com.br

Antonio Fonfría Mesa
PhD in Economic Sciences
Professor at the Universidad Complutense de Madrid
Madrid, Spain
afonfria@ccee.ucm.es

Abstract

This study examines how the cultures of innovation of the Brazilian Army and the Brazilian Navy influenced the RDS-Defence innovation process. RDS-Defence, or Software-Defined Radio for Defence, is a programme of the Brazilian Ministry of Defence that seeks to develop radios for tactical communications within the Brazilian Armed Forces. The study aimed to determine which elements of the Brazilian Army and Navy's culture of innovation have either facilitated or hindered the RDS-Defence innovation process. This is an exploratory and qualitative study. A literature review was used to collect data from books, documents and semi-structured interviews with officers who work or worked in the RDS-Defence team. The collected data were analysed using Content Analysis techniques.The findings show that the Armed Forces' culture of innovation does indeed influence innovation processes. Certain elements of culture of innovation acted as catalysts for innovation, while others impeded the speed of the innovation process to some degree.

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Keywords: Culture of Innovation; Military Innovation; Brazil.

Resumo

O objetivo da pesquisa foi identificar de que forma a cultura de inovação do Exército Brasileiro e da Marinha do Brasil influenciou o processo de inovação do Rádio Definido por Software de Defesa (RDS-Defesa). O RDS-Defesa é um programa promovido pelo Ministério da Defesa do Brasil e visa realizar o desenvolvimento de rádios para as comunicações táticas das Forças Armadas do Brasil. Nesse sentido, procurou analisar-se que elementos da cultura de inovação, do Exército Brasileiro e da Marinha do Brasil, estimularam ou dificultaram o processo de inovação do RDS-Defesa. O estudo tem caráter exploratório de cunho qualitativo, os dados foram recolhidos por meio de bibliografias, documentos e entrevistas semiestruturadas dirigidas ao universo de militares da equipa do RDS-Defesa. O tratamento dos dados foi realizado por meio da técnica análise de conteúdo. Os resultados demonstraram que a cultura de inovação das Forças Armadas do Brasil influencia os processos de inovação. Alguns elementos que compõem a cultura de inovação agiram no sentido de alavancar as inovações e outros acabam por inibir, nalguma medida, a velocidade do processo de inovação.

***Palavras-chave*:** *Cultura de Inovação; Inovação Militar; Brasil.*

1. Introduction

This study analyses the relationship between the culture of innovation of the Armed Forces and the creation of innovative products[1]. Dobni (2008) defines the Culture of Innovation concept "as a multidimensional context which includes the intention to be innovative, the infrastructure to support innovation, operational level behaviours necessary to influence a market and value orientation, and the environment to implement innovation" (p. 540).

Most of the scientific papers on "military organisational culture" analysed in the literature review do not focus on innovation. They generally address topics such as: the military career; the impact of culture on strategy (Builder, 1989); and how cultures external to the organisation influence military routine (Soeters, 1997; Soeters & Recht, 1998).

This study aims to contribute to the body of knowledge on military organisational culture by identifying and analysing the elements of the Brazilian Armed Forces' innovation culture that influenced the innovation process of the RDS-Defence programme. The research question that will be answered is: how have the cultures of innovation of the Brazilian Army and Navy influenced the innovation process of the Software-Defined Radio (SDR) programme of the Ministry of Defence?

RDS-Defence is a comprehensive national Research and Development (R&D) programme of the Brazilian Ministry of Defence in cooperation with the Brazilian Army and the Brazilian

[1] This study was conducted as part of a dissertation funded by the Rio de Janeiro State Research Foundation (FAPERJ).

Navy. Its aim is to develop radios that meet certain requirements, including interoperability between different communication systems, cyber security and protection against attacks and interception. The programme also aims to ensure the availability and reliability of communications in adverse, high-pressure environments. The programme began in 2012 and the final phase of its first research and development cycle was underway at the time this study was prepared (2019 / 2020).

An exploratory qualitative approach was used as the study methodology. A literature review was conducted to collect data from documents and semi-structured interviews with officers who worked in the RDS-Defence team since 2020. The data were transcribed and processed using MAXQDA software and Content Analysis (CA) techniques. The content analysis method consists of a set of communication analysis techniques (Bardin, 2004). It uses systematic procedures to describe the content of a message, to identify the conditions in which the message was produced / received (who produced it, in what context and / or what effects it aims to create) (Bardin, 2011).

The paper is organised in the following manner: after this introduction, a theoretical framework is provided to introduce the theories about innovation culture and the innovation process on which this study was based. The next section is the methodological framework, which describes the technical and methodological approaches used in the work. Next, the data collection and analysis section investigates the influence of certain aspects of the cultures of innovation of the Brazilian Navy and the Brazilian Army on the RDS-Defence innovation process. Finally, the conclusion section contains the findings and suggestions for future studies.

2. Theoretical and conceptual framework

Several studies on management have attempted to identify the main determinants of innovation in the private sector. These studies can be divided into two fields. The first field explores organisational culture specifically and attempts to determine its relationship with innovation. Most studies in this field are based on either Schein's theoretical concept (1984) or Hofstede's model (1980). Some studies, albeit less, are based on the Competing Values Framework by Quinn (2011) and on the cultural profile model by O'Reilly et al. (1991).

The second field includes studies that assume that culture is a determining factor and develop theoretical models on how organisational culture can be changed to foster innovation (Bruno-Faria & Fonseca, 2014). The studies that focus exclusively on the Culture of Innovation construct are usually based on the concept proposed by Dobni (2008) presented above. In general, studies on Innovation Culture assume that the organisation should have structures and / or processes that enable new ideas to evolve to the implementation stage (Streets & Boundary, 2004).

An article by Zien and Buckler (1997), From experience dreams to market crafting a culture of innovation, describes one of the first studies to explore the Culture of Innovation construct specifically. The authors interviewed experts from different companies to understand how they maintain a strong and vibrant spirit of innovation. The study found seven characteristics

that are common to all companies, regardless of the variables 'mission', 'geographic location' or 'nationality' (Zien & Buckler, 1997). This work was instrumental to develop Innovation Culture as a field of study, both theoretically and methodologically (Jassawalla & Sashittal, 2002; Kalyar & Rafi, 2013; Kenny & Reedy, 2006; Lyons et al., 2007).

In addition to these studies that analyse Innovation Culture in the private sector, the literature review also revealed studies about the public sector. Common sense dictates that the public sector is perceived as not welcoming innovation (Borins 2001). It was only in the 1990s that this reputation was challenged by science (Frederickson & Johnston, 1999). Since then, the literature on the culture of innovation in the private sector has been enriched by a growing number of studies on the public sector (Koch & Hauknes 2005), which follow at least two well-defined avenues of research. One analyses case studies (Koch & Hauknes, 2005), while the other focuses on quantitative analysis (Borins, 2001; Vigoda-Gadot et al., 2005).

In the latter, an important study by Lægreid et al. (2011) examines the innovative culture and activities of 121 Norwegian and Flemish state agencies. This study by Lægreid et al. (2011) aimed to identify the factors that foster an innovative culture and promote innovative activities in state agencies. The research was based on surveys and data available from a data platform. The survey showed that most agencies believe they have an innovative culture and that they can develop highly innovative products and services.

As for Brazilian studies on the relationship between innovation culture and public environments, there is a growing body of literature that aligns with international trends (Brandão & Bruno-Faria, 2017; Carbone, 2000; Ferreira et al., 2014; Pires & Macêdo, 2006). However, studies that focus specifically on innovation culture in Brazilian military institutions are scarce, and most are dissertations prepared for military courses which have not been adapted into peer-reviewed scientific articles. Of the studies published in scientific journals on administration and strategic studies, the ones by Louro (2005) and Franco-Azevedo (2018) is particularly relevant.

Louro (2018) analyses how the culture of the Brazilian Army Cavalry influenced that Arm's mechanisation process. Franco-Azevedo (2018) proposes five elements that can be used to analyse the culture of innovation in the defence sector: Agents' Interests (Illusio); Innovation Value Factors (Valorem) in the agents' organisational culture; Alliances for Innovation (Alliances); Benefits of Alliances (Beneficium) and Innovation Supporting Factors (Capitis). Table 1 lists the items that constitute the elements of analysis proposed by Franco-Azevedo (2018).

Table 1 – Innovation Culture - Elements of analysis

Agents' interests	Benefits of Alliances	Value factors	Alliances for innovation	Supporting factors
What is at stake? (*illusio*)	Why establish alliances? (*beneficium*)	What are the stakeholders' preferences? (*valorem*)	What types of interactions exist? (*alliances*)	What is at stake? (*capitis*)
- Various motivations (economic, political, military, psychosocial our scientific-technological); - Individual, sectoral, organisational and governmental interests; and - Interests may be divergent or harmonious.	- The specific or visualised outcomes of the alliances; - There are benefits for each stakeholder: the Armed Forces, the DIB, the IES and the government; and - They can be specific to one stakeholder or common to several.	- Which values are the decisions to innovate based on? - Values can be inducing or inhibiting.	- Intra- and inter-organisation relationships; - How many stakeholders participate in the alliance? - Types: cooperation, partnership, collaboration, arrangements, compensation agreements (Offset; industrial compensation), etc.	- Physical, human and organisational aspects that enable creativity, learning and team work; - They include Production Structures (What I have) and Institutional Definition Structures (What I want); and - They can be encouraging or discouraging.

Source: Adapted from Franco-Azevedo (2018)

According to Franco-Azevedo (2018), to analyse culture, first one must identify the Agents' Interests. This category includes all the motives that make an agent to want to innovate. However, the word 'interest' could have negative connotations. Franco-Azevedo (2018) state that it is commonly used to refer to profit, gains or advantages, but add that it also has other meanings. Mauss (1985) explains that it also refers to attention, benevolence, curiosity, good will and solidarity. In this study, the category Agents' Interests refers to both: interests in the sense of benefits and the act of taking an interest in something or someone. It should be emphasised that these 'Interests' can be either harmonious, when agents have similar interests, or dissonant, when those interests clash (Table 1).

The Value Factors category refers to the values which drive the agents' preferences. According to Oliveira and Tamayo (2004), values are important elements of innovation culture. It is the values established by senior managers that show the organisation's preference for certain behaviours, goals or strategies. Based on the work by Oliveira and Tamayo (2004), Franco-Azevedo (2018) compiled a list of preferences that defence sector stakeholders prioritise when signing alliances. The 15 values mapped by the author are Innovation Value Factors (IVF) for the defence sector. They are divided into values that induce and values that inhibit innovation. Inducing values contribute to the creation of an environment that fosters innovation in the Defence sector: Autonomy; Reliability; Sprit-de-corps; Harmony; Egalitarianism; Proactivity; Achievement and Resilience. On the other hand, inhibiting values tend to maintain the status quo: Conservatism; Dominance; Hierarchy; Standardisation; Security and Vanity.

The Benefits of Alliances category, according to Franco-Azevedo (2013), refers to the gains, improvements and benefits visualised by the agents during the innovation process. In other words, benefits are the concrete outcomes of alliances or of the act of visualising their potential outcomes. It is different from the category Agents' Interests, which refer to desires that can be achieved without the need for partnerships.

Partnerships are established by weighing the interests and preferences of the agents against the benefits visualised through interactions. This process is represented by the "Alliances for Innovation" element. According to Franco-Azevedo (2018), the more intense these partnerships are, the better the system's performance will be. For the author, innovation depends essentially on the interactions (Alliances for Innovation) between the agents in an innovation system (Franco-Azevedo, 2013). However, partnerships alone do not drive innovation (Franco-Azevedo, 2018). According to the author, Innovation Supporting Factors (ISF) are also necessary for innovation to take place.

ISF include physical, human and organisational elements that support or drive innovation (Franco-Azevedo, 2018). They can be grouped as follows: Learning with the environment; Commitment of senior management; Extensive communication; Teamwork; Continuous individual development; Organisational structure; People management; Key Individuals and; Physical Infrastructure for Innovation. Each category can contribute to the innovation process (Inducing Factors) or inhibit it (Inhibiting Factors). Finally, the better positioned the agents are regarding these factors, the greater their motivation to seek cooperation, that is, agents with weak ISF do not encourage the formation of alliances (Franco-Azevedo, 2018, p. 158).

In this study, the innovation process is examined using the concepts and analyses provided by Myers and Marquis (1969). These authors view innovation as "not just the conception of a new idea, nor the invention of a new device, nor the development of a new market. The process is all these things acting in an integrated fashion (Myers & Marquis, 1996, p. 2).

Myers and Marquis (1969) add that the innovation process has three main phases: idea generation (concept generation), problem solving (technical activities to develop the idea) and implementation and dissemination. This theory is illustrated in Figure 1.

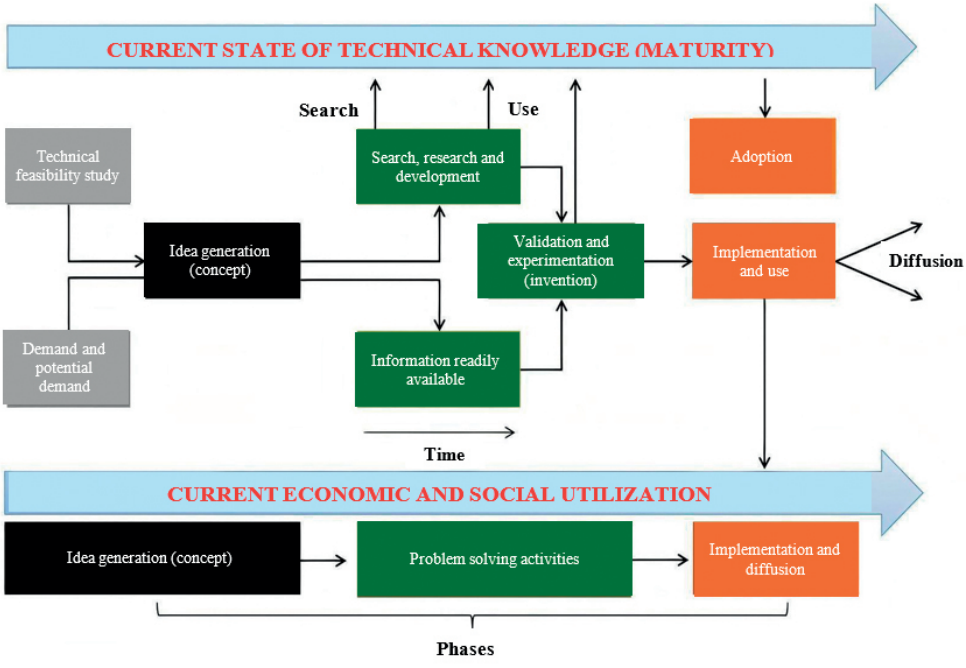

Figure 1 – Technological Innovation Process
Source: Adapted from Myers & Marquis (1969).

In the Idea Generation phase, a proposal is developed to integrate 'market demand' and 'technical feasibility'. At this stage, both perspectives must be taken into account, as technical progress alone may or may not provide a solution to the demand. Likewise, the attempt to respond to a demand may or may not lead to a solution, depending on technical feasibility and the current technical knowledge (Myers & Marquis, 1969).

In the Problem Solving phase, according to Myers and Marquis (1969), the information and knowledge required to create the innovation are examined. This knowledge may be already available in some cases, while in others, research and development (R&D) activities need to be carried out (Myers & Marquis, 1969). This phase includes activities that aim to validate knowledge or products associated with identified demands. In other words, it is the period during which one assesses if the results obtained so far meet the project design specifications or if it will be necessary to suggest changes to the proposal. However, having to make changes to the technical planning does not constitute an innovation failure. In fact, the authors point out that problems and unforeseen events are associated with the development of new solutions, and that they can be overcome by searching for alternative solutions or even new objectives (Myers & Marquis, 1969).

The third and final stage, Implementation and Diffusion, corresponds to the implementation of the solution and its introduction to the market (Myers & Marquis, 1969). According to the authors, this last stage is not always a given, as only one or two out of five new products

generate profits that provide a return on the investment made in the innovation. In most cases, this stage is also the most costly, since the initial production costs and the cost of promoting and distributing a product are usually much higher than the costs of obtaining the solution (Myers & Marquis, 1969).

3. Methodology

A qualitative exploratory approach was used to conduct the investigation. The decision to conduct an exploratory study was based on the fact that this is the first work that deals directly with the study topic, RDS-Defence. Another reason for this choise is that a literature review revealed few extant studies on innovation culture in military environments.

Before describing the research techniques, it should be mentioned that the collected data refers to the data available until the end of the first half of 2020. During this period, the first SDR Research and Development cycle was underway, which involved designing prototypes of vehicular radios that can be installed on naval and land vectors. The second cycle, which had not yet begun, would involve the development of smaller and lighter radio prototypes. This means that the study is only a partial analysis. The data observed can be revisited in future studies to provide more comprehensive analyses.

Even though the programme was still underway, this study was relevant because the SDR innovation process has been ongoing for over nine years. In Myers and Marquis (1969) theory, this period occurs during the 'Idea Generation' and 'Problem Solving' phases, but not during the 'Implementation' phase of the process. Therefore, there was enough data to analyse the influence of innovation culture on the RDS-Defence innovation process (Prado et al., 2017).

The data collection techniques, as mentioned above, included a literature review of books and documents, as well as semi-structured interviews. The interviewees were selected based on the criteria proposed by Lincoln and Guba (1985). The universe of military personnel selected for the interviews was based on the participants' position, role and how long they worked on the programme. A total of 12 interviews were conducted with Brazilian Navy and Army officers who were supervisors, managers or technical staff. The interviews did not include Brazilian Air Force (BAF) officers because, even though the SDR programme is coordinated by the Ministry of Defence and the goal is to enable interoperability between the three forces, the BAF preferred to focus on a proposal that analysed an aviation solution, LinkBR. Therefore, only team members from the Naval and Land Forces were interviewed and, consequently, the analyses in this study only examine these cultures[2].

The interviews were conducted according to the principles of ethical integrity in human experimentation (Brazil, 1996) and their trustworthiness was guaranteed by the general research requirements (Thiry-Cherques, 2008). The protocol proposed by McCracken (1988) was used for all interviews.

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[2] While the Air Force's innovation culture may have influenced that Force during the first phase of the innovation process – Idea Generation – it was not possible to identify and interview the officers from that branch who participated in that phase. Therefore, the influence of the Brazilian Air Force's culture of innovation on the innovation process was not analysed. Time constraints also contributed to this decision.

With regard to how the data collected was processed, as mentioned in the introduction, Content Analysis (CA) was performed using MAXQDA software. The data collected from the interviews were processed and systematised in the three stages outlined by Bardin (2004, p. 125): pre-analysis, analysis of the material and interpretation of the findings.

The study used the following categories, which are similar to those adopted by Franco-Azevedo (2018): Agents' Interests; Innovation Value Factors; Benefits of Alliances and Innovation Supporting Factors (Franco-Azevedo, 2018, p. 309). The study aimed to identify the influence of the innovation process categories proposed by Myers and Marquis (1969) on the RDS-Defence programme. The data were analysed by comparing the elements used to analyse innovation culture with the stages of the innovation process, as illustrated in Figure 2.

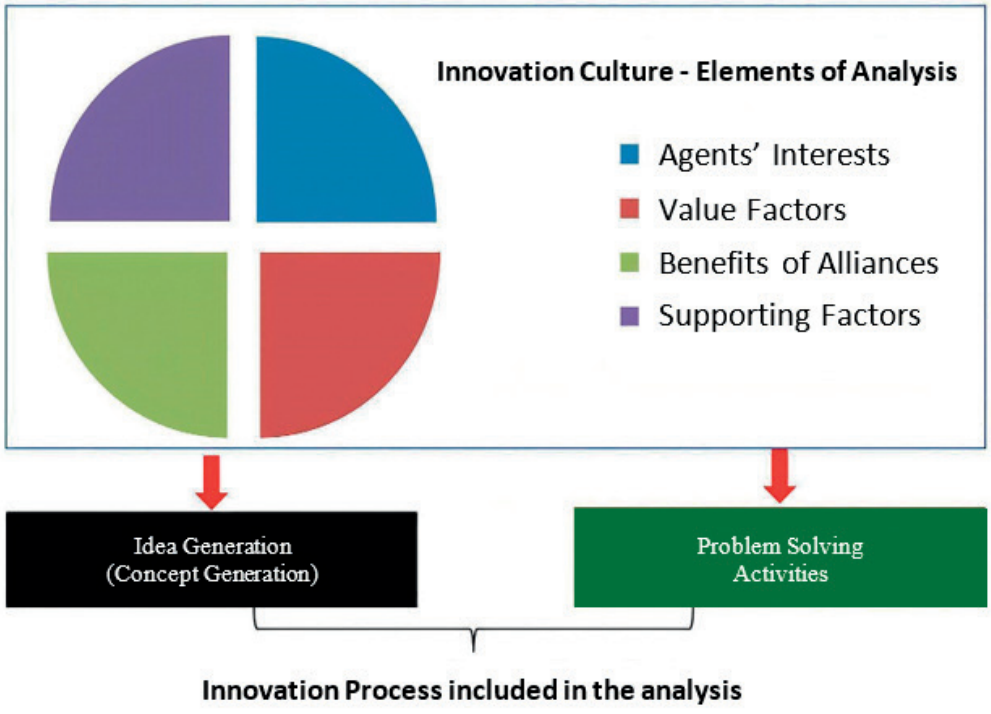

Figure 2 – Data analysis diagram

4. Analysis of data

The innovation process presented here is divided in three main phases: Idea Generation; Problem Solving; and Implementation (Myer & Marquis, 1969). Each stage corresponds to a specific challenge and is characterised by different types of decisions, coordination problems and communication patterns (Allen, 1984). Based on this theory, this section analyses the impact of the innovation cultures of each Force on the first two phases of the RDS-Defence innovation process (since the programme has not reached the Implementation phase yet). The impact of these cultures on Idea Generation is analysed before addressing the Problem Solving phase.

4.1. First phase of the RDS-Defence innovation process: Idea Generation

Successful innovations begin with a new idea, which comes from an awareness of its technical feasibility and the demand for a product (Myers & Marquis, 1969). In this phase, both aspects must be taken into account because an innovation based on technical feasibility alone may lead to a solution for which there will not be a demand. Likewise, an innovation based simply on a demand may not lead to a solution, depending on its technical feasibility and the current state of technical knowledge (Myers & Marquis, 1969).

Having analysed the data and documents on the RDS-Defence Programme, it was clear that the project team had prepared both stages: current or future demand and technical feasibility. The reason for this was that the programme was created by combining the SDR proposals that each Force had already prepared. Therefore, each Force made its own assessment of demands and, once the decision had been made to develop an interoperable radio, the combined demands were assessed. To explain how the various proposals were combined, a brief description of each Force's interests in the SDR technology will be provided.

First, communications are a sensitive area for national defence. Consequently, all the Forces had an 'Interest in Innovating' in that area even before there was a proposal for an interoperable radio. Second, the 'interests' of the Brazilian Navy and the Brazilian Army in this area were aligned (or harmonious). Both forces had the same motivation: to stop acquiring communication systems from foreign companies and begin producing them in Brazil, as had been done in the past.

At that time, the Brazilian Army had a proposal for a radio system that could be implemented in a period of ten years, with a budget of 100 million *reais*. The Brazilian Navy presented a proposal that would take three (3) years to develop, with a budget of 10 million *reais*. Both projects were presented in 2011 at the Meeting of Defence Projects of Interest in Science, Technology and Innovation (REPID)[3]. After the Brazilian Army's project was presented, the then Secretary of Science and Technology of the Brazilian Navy deemed the SDR proposal of the Brazilian Army to be suitable for the Naval Force. Later, it was decided that the SDR would be a joint project between the Brazilian Army, the Brazilian Navy and Aviation, managed by the Brazilian Ministry of Defence, as set out in article 2, item I of Order No. 2.110 of the Brazilian Ministry of Defence, published on 9 August 2012.

The Brazilian Navy's decision to adopt the Brazilian Army's proposal was, in fact, the first time that the Forces' culture of innovation had an impact on the RDS-Defence innovation process. In other words, the Secretary of Science and Technology of the Brazilian Navy noted at the time that the interests of the Naval Force and the Land Force in the field of communications aligned, that is, were harmonious, which meant that there would be clear benefits in carrying out the project jointly.

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[3] REPID is organised by the Brazilian Ministry of Defence. During the meeting, the status of ongoing projects is updated and new projects are proposed to improve force interoperability (Brazil, 2014).

This brings to mind the difference between Benefits and Interests discussed earlier. Benefits come from interactions, while Interests are motivations of all types (Franco-Azevedo, 2018). That is, agent' interests' can be achieved without the need for partnerships, whereas benefits arise from them. When deciding to create the programme jointly, the Brazilian Army and the Brazilian Navy not only achieved their Interests, but also calculated the Benefit of sharing the costs and risks of the programme, which include human resources, budget, personnel and infrastructure.

Once the Brazilian Ministry of Defence approved the proposal for a joint radio system, a new assessment of demands was prepared, which now included the operational scenarios of the three forces. The reports show that this phase consisted of intense meetings in which disagreements were common. The interviews revealed that each force had its own way of managing, administering and developing R&D programmes, which did not align with the others'.

Based on this data, it is possible that these differences were influenced by Inhibiting Value Factors. Radio technology has high strategic value for the Forces and each force has its own distinctive operational scenarios. The Security Value Factor (which is similar to the "uncertainty avoidance" dimension and comes from the need for individual and collective protection and stability) likely had a strong influence during this period.

One aspect on which the forces disagreed was scheduling. The Brazilian Navy initially aimed to deliver the product in three years because it needed it to meet the demands of the Force. For the Brazilian Army, ten years was the minimum to research and develop such sensitive and complex technology, as suggested by the market benchmarks.

The data also shows that there was another point of contention influenced by Inhibiting Value Factors. The discussion on which Force would host the programme was clearly influenced by the Safety IVF and the Dominance IVF. The Dominance factor highlights the organisation's concern with strategies associated with competition (in the sense of dispute) and individualism. As there was still no consensus on which requirements the RDS-Defence would meet, it is possible that neither Force trusted the other to lead the project because it feared that it would not meet its needs.

According to the officers interviewed, the shift from a state of disagreement to a unified vision occurred when the Brazilian Navy and the Brazilian Army supervisors at the time worked together to come up with a proposal that was suitable for both Forces. In other words, all the forces' needs were taken into consideration, in order to harmonise the agents' interests.

It was at that moment that the culture of innovation began, once again, to influence the RDS-Defence innovation process. Even though the Forces were influenced by Inhibiting Value Factors during the initial discussions, there was an effort to align the Inducing Value Factors to ensure that the solutions would be suitable for all agents. It was possible to ascertain from the collected data that the actions of the Naval and Land Force supervisors were influenced by the Trust and Resilience Value Factors. The Resilience factor motivates people, groups and companies to remain committed to their objectives (Rutter, 1987) and plan innovative solutions to problems that may arise (Tavares, 2001). The Trust factor is the stakeholders' willingness

to be vulnerable to the actions of another, based on the belief that the latter will complete an important task without the need for monitoring or supervision (Mayer et al., 1995).

When the supervisors endeavoured to align these Inducing Value Factors, the result was a proposal that harmonised the demands of all the forces. It was decided that the RDS-Defence Programme would include two Development Cycles. The first cycle would involve producing prototypes of vehicular radios that could be installed in naval and land platforms. It would occur over 10 (ten) years and have a budget of 100 million reais, as in the Brazilian Army's vision, with intermediate deliveries at dates that met the needs of the Brazilian Navy (Prado et al., 2017). In the second cycle, prototypes would be developed of smaller, lighter radios known as handheld and manpack, with a budget of 90 million reais and an estimated delivery time of five years (Prado et al., 2017).

Having aligned the scenarios which the SDR would cover, a technical and structural feasibility survey was carried out. More than 70% of interviewees said that this was the phase that required more resilience and proactivity by the military personnel involved. As the programme was highly complex in technological terms, it implied a considerable initial investment. It also required a robust, multidisciplinary team with qualified and experienced engineers in the fields of communications, electronics and telecommunications.

At that moment, the joint efforts of all military personnel from all the forces were vital for the project to move forward. The Head of CTEx (Army Technology Centre) at the time provided a physical space and personnel and the Naval Force manager sought to establish agreements to ensure that Military Engineers were available to work full-time at CTEx, as did supervisors, and obtained support from CASNAV and the Navy Research Institute. The Value Factors Proactivity and Resilience can be identified in this joint effort by the team. According to Bateman and Crant (1996), proactivity is the ability that drives an individual or group to shape their environment without being limited by external circumstances.

With regard to the initial financial investment made by RDS Defence, the reports showed that in 2012, even though the budget was not completed yet, it was possible to begin defining the tender processes. The excerpts from the interviews revealed that, even though the prospects of obtaining funding for research were discouraging, the programme team looked for resources in the cyber sector. This suggests, once again, that the culture of innovation influenced the RDS-Defence innovation process. It was clear that the team shared values associated with the Proactivity Value Factor.

Despite these efforts, the funds that were raised were not enough to implement the two R&D cycles simultaneously. According to an article by Prado, Galdino and David published in 2017, the SDR's second R&D cycle was not implemented due to budget restrictions (Prado et al., 2017). This means that, even when positive value factors influence the innovation process through the project team, the programme will not be successful without supporting factors.

4.2. Second phase of the RDS-Defence innovation process: Problem Solving

The culture of innovation influenced the Problem Solving Activities in four aspects: the organisational structure of the programme; the way in which the knowledge produced was

managed; the issues related to the budget; and way in which the programme was validated and tested. First, this section will discuss the impact of culture on the programme's organisational structure and on the dynamics of the SDR R&D decision-making. Next, it will describe the impact of this culture on how the knowledge produced in the modules is managed and documented. Finally, it will address the impact of innovation culture on the budget for the R&D phase of the programme, and, finally, on the validation and experimentation stage.

The first RDS-Defence research and development cycle began in December 2012, when a private partner was contracted, the *Fundação Centro de Pesquisa e Desenvolvimento em Telecomunicações*, a Research and Development Centre in Telecommunications. It was decided that the programme's organisational structure would consist of one Manager, the Commander of CTEX; two supervisors, one from the Brazilian Navy and one from the Brazilian Army; a management team and; a technical team.

During the research phase, the management team consisted of officers who were already working in technical roles in the programme and had the expertise required to perform bureaucratic tasks. Younger military personnel worked in the technical area. This included lieutenants and captains from the Army and their counterparts in the Brazilian Navy, who only dealt with technical issues, and seldom with contract-related activities.

It was clear from the reports that the officers were pleased to have set up this system, even if the structure is not entirely efficient. The way the teams are organised means that officers with more experience are not as involved in R&D activities, which leads to a relative waste of intellectual capital.

If the RDS-Defence had specialised officers tasked exclusively with dealing with bureaucratic issues, more experienced and qualified officers (engineers) would be free to focus on the technical development of the programme. This means that there is room for improvement in the Commitment of Senior Management category, specifically with regard to the availability of officers from the Complementary Staff to carry out purely administrative activities.

Despite this criticism of the way the programme is structured, it is worth highlighting the officers' commitment to finding a solution to minimise the impact of the lack of human resources. The management team's decision to deal with bureaucratic and contractual issues in order to allow less experienced professionals to deal exclusively with the technical aspects shows that the members of the programme team were influenced by the Value Factor *Sprit-de-corps*. According to a document titled *Structuring Military Leadership*, this factor is the value represented by the feeling of camaraderie and solidarity among the members of a group after they have completed or are in the process of completing challenging tasks (Brazil, 1991). It was this VF that allowed the team to deal with the challenges they encountered.

The other situation in which this study identified the influence of innovation culture was in the management of the knowledge obtained in the first R&D cycle of the RDS-Defence programme. There is a high turnover of officers in the programme, which affects the R&D process because when these professionals leave, there is also a loss of knowledge and experience. According to the reports, this turnover is inherent to the military career. Even so,

it is an issue that needs to be addressed, especially with regard to knowledge management. To bridge this gap, the RDS-Defence team considered the option of mapping and managing knowledge as a way of countering the negative effects of turnover on the programme. As a result, in 2017, there was an initiative to integrate a pilot project by AGITEC (Technological Management and Innovation Agency), which focused on integrating knowledge management processes into the RDS-Defence programme.

This initiative once again shows the team's proactivity, and confirms that the Proactivity Factor can influence the innovation process. The military's readiness to find knowledge management solutions to counter the effects of turnover is precisely what is described in the definition of the proactivity factor. These activities not only minimised the effects of knowledge loss, but also provided new training techniques that continue to be used today.

Furthermore, it shows that innovation culture has had an impact not only on how knowledge is mapped, but also on the way in which it is codified. One of the options to minimise the impact of officer turnover in the programme was the incentive to transform tacit knowledge into codified knowledge, in other words, to convert the knowledge acquired through experience into manuals and transcripts. However, as the programme is multidisciplinary, a specific methodology had to be created to convert the information so it could be understood by any area of knowledge involved in the innovation process.

This commitment to develop a methodology that allowed any area of knowledge related to RDS-Defence capabilities to use that knowledge symbolises, once again, the influence of the Proactivity Value Factor in the SDR R&D process. This initiative showed the sense of responsibility, which in this study is referred to as *Sprit-de-corps*, that drove the team to find a way of converting the knowledge acquired through experience into manuals and other transcripts, so that, in the future, it could be used and understood by the areas responsible for mechanics, electronics, electricity, telecommunications or computing. According to the document Structuring Military Leadership, the Value Factor *Sprit-de-corps* is the collective soul of the members of an organisation (Brazil, 1991).

Another situation where the culture of innovation showed its influence was in the RDS-Defence budget. In 2017, the programme was included in the Annual Budget Law. Thus, it is clear that senior managers were committed to the budgetary aspects of the programme, as a specific item was created for it in the budget. However, only 20% of the total funds were allocated that year, which led to delays and required exceptional efforts to find other sources of funding. To solve the problem, the RDS managers had to rely on support from the Brazilian Army.

Once again, the Proactivity Value Factor encouraged the team to prevent situational vectors from affecting the programme in an extremely negative way, which led them to look for alternative sources of funding. Furthermore, the decision of the Brazilian Army to make those funds available shows the commitment of the Land Force's senior managers to the programme.

The last situation in the Problem Solving stage where the influence of the culture of innovation could be felt was in the validation and experimentation phase. As mentioned earlier, throughout the process, the programme team held frequent meetings, which included in their agenda, when needed, the possibility of changing or refining technical specificities according to the demands proposed by the Forces.

This shows that the Brazilian Navy is committed to updating requirements as needed to align them with the operational needs. All interviewees from the Naval Force mentioned this effort to work closely with the operational sector and to integrate any existing demands into the research and development of the programme. It is worth noting that this topic (working closely with the operational sector) was not mentioned in the interviews with Brazilian Army officers. However, this does not mean that the force is not interested in the needs of its soldiers. The interview did not include a specific question on the subject, but as it was semi-structured, the interviewees had some degree of freedom to address topics they felt were relevant to the questions they were asked.

In any case, it was interesting to note that all Brazilian Navy interviewees mentioned the subject, even though the interviews were conducted individually. One explanation for this could lie in the officers' training. Military engineers in the Brazilian Army are graduates of the IME, and many attended the Agulhas Negras Military Academy. Therefore, their contact with the operational sector is more dynamic, and perhaps even more informal due to their interaction in courses throughout their careers. This natural interaction may thus be seen as not being important enough to mention in an interview.

On the other hand, the vast majority of engineers in the Brazilian Navy graduated from civilian universities, and their contact with the operational sector is more standardised and formal, making it more relevant to their descriptions of the military research and development process. This may suggest that the Brazilian Navy team proactively seeks to identify demands, even if their relationship with the operational sector is not as simple and dynamic.

If, on the one hand, the Force's reasons for making these efforts are not methodologically strong enough to be considered analyses rather than speculations, on the other hand, it is clear that these activities had an impact on the programme. Through this constant contact with the operational sector, the SDR system has acquired specific technical characteristics that make the end product more attractive to the Brazilian Navy.

In the RDS-Defence experimentation stage, an interesting development resulted from the demonstration held at LAAD Defence & Security 2019. LAAD Defence & Security – the international defence and security trade fair – is the most important event of this type in Latin America. The exhibition aims to promote the defence and security sectors, both nationally and in Latin America, by providing access to the latest global technologies and services, as well as allowing local companies to show their innovations to representatives from more than 80 nations.

At the time, the RDS-Defence emitted two waveforms in real time. A Guarani vehicle with the radio installed was parked outside, and another prototype was installed inside, at

a distance of about 100 metres. The team demonstrated the radio's capacity, which no other participant did. This indicated the presence of the achievement value factor, which Oliveira & Tamayo (2004) described as the personal success obtained by showing competence, which leads to social recognition.

The most important impact on the RDS-Defence innovation process which resulted from this exhibition was the exposure of the SDR programme to the high echelons of the Forces and to the Brazilian Ministry of Defence. More than 90% of interviewees stated that LAAD 2019 had a significant impact on the programme, as the senior hierarchy was able to witness the technological maturity of the project. According to the interviews, after the demonstrations, many strategic decision-makers contacted them to suggest a demand or to offer assistance and resources.

5. Conclusion

This study aimed to determine how the cultures of innovation of the Brazilian Army and Navy influenced the RDS-Defence innovation process. This was done by conducting a literature review of books and documents on the topic and interviews with officers who participated in the programme during the research phase (2020). With regards to methodology, the data were analysed by performing a Content Analysis with the following categories: Agents' Interests; Innovation Value Factors; Benefits of Alliances and Innovation Supporting Factors (Franco-Azevedo, 2018, p. 309). The study used the innovation process concept proposed by Myer and Marquis (1969), which consists of three major phases: Idea Generation; Problem Solving and Implementation. At the end of 2020, the last phase of the topic of this study (the RDS Programme) was not yet underway. Therefore, the study only covered the first two stages. The data was analysed by comparing the factors used to analyse innovation culture with the stages of the innovation process.

The findings show that the Forces' innovation culture does indeed influence innovation processes. Certain elements of the culture of innovation acted as catalysts for innovation, while others, to some degree, impeded the speed of the innovation process. In the case of the RDS Programme, the Inducing Value Factors shared by the development team were essential to overcome the obstacles and barriers to the innovation process of this defence product. The table summarising the research findings, titled Appendix 1, contains the relevant aspects that confirm this. Despite the challenges that emerged in each phase, such as the presence of diverging interests, inhibiting values and discouraging supporting factors, it was the benefits visualised by the Forces and certain inducing values that made the Programme a success.

One of the aspects responsible for friction during the development of the RDS-Defence innovation process were: turnover; the specific needs of the Forces when managing their human resources; a certain degree of initial mistrust among stakeholders, especially with regard to the governance model for the RDS programme; and the difficulty in securing funding. These factors did not prevent the process from moving forward, but influenced the speed at which the equipment was developed.

On the other hand, certain factors helped the innovation process to flow, minimising friction and helping to overcome barriers and limitations, allowing the programme to reach its current status. One factor that drove the team's desire to overcome difficulties was the need for communications interoperability between the Forces in order to reduce the dependence on foreign nations to obtain Defence Products related to communications (SDR).

Another fact that should be highlighted was the high level of commitment of senior managers and leaders, who sought solutions to overcome the lack of financial resources. This was especially noticeable in 2017, when: a specific item was created in the Annual Budget Law for the development of the RDS-Defence programme; suitable laboratories and infrastructure were made available for R&D activities; and the efficiency with which the knowledge produced was managed was improved by preparing programme-specific manuals and standards. However, the environment that enabled the success of the SDR initiative was enabled by the presence of inducing value factors: the resilience of the development team; security and reliability among stakeholders during the process; the *sprit-de-corps* and team spirit that emerged from the team's interactions; and the proactivity and foresight of those who managed the innovation process.

Finally, it is worth remembering that the Implementation phase, the last stage of the innovation process during which the product is introduced to the market and the solution is put into use, had not yet started when this study was completed. Therefore, as the Forces are the potential clients of this product, future studies should be conducted to determine how the innovation culture of the Brazilian Navy and the Brazilian Army influences the way in which it is introduced to the market.

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APÊNDICES

Appendix 1 – Findings

Phase	Elements of Analysis	Types	Relevant aspects
Idea Generation	Agents' Interests	Harmonious	- Interoperability of communications between the Forces; - Reducing the dependence on foreign nations to obtain Defence Products related to communications (SDR); - Portfolio is managed at ministry level (Min Def)
		Dissonant	- Project proposals with different schedules and applications for each Force. Obs.: the dissonance was overcome by changing the demands and by the presence of inducing values (see IVF below)
			- Initially, the project's governance was a point of contention among managers. Obs.: the dissonance was overcome through existing IVF (the way in which R&D processes are managed, administered and developed)
	Benefits of Alliances	Clearly visualised	- Sharing the risks when managing projects - Sharing infrastructure and laboratories - More opportunities for interoperability - Sharing human and financial resources
	Inducing Value Factors (IVF)	Resilience Security Sprit-de-corps Proactivity Reliability	The listed IVF helped solve disagreements, including: - dissonant interests regarding the project's applications and schedule differences in deadlines, - phases and schedules, - uncertainty regarding governance Inducing IVF were identified in several situations, such as the training provided to the work team, the moment when the required infrastructure was made available, and even in the search for funding
	Inducing Value Factors (IVF)	Security Dominance	- Uncertainty and mistrust between the teams of the Forces during the idea generation phase, especially regarding the SDR programme's governance model

[Cont.]

	Innovation Supporting Factors (Physical Infrastructure for Innovation; Commitment of senior management; Organisational structure; Key Individuals; Continuous individual development; Extensive communication; Teamwork; Learning with the environment; and People management)	Encouraging	- High level of commitment by the Forces' senior management shown in the allocation of qualified human resources to work on the programme full-time - Availability of suitable laboratories and infrastructure for R&D activities - Extensive communication, learning with the environment and team work were essential to minimise the negative effects of dissonant interests and inhibiting value factors
		Discouraging	- Difficulty estimating the budget
Problem solving	Agents' Interests	Harmonious	The same aspects that were identified in the idea generation phase
		Dissonant	The same aspects that were identified in the idea generation phase
	Benefits of Alliances	Clearly visualised	- Improved efficiency in the way the knowledge produced was managed by developing a methodology to codify information
	Inducing Value Factors (IVF)	Resilience Security Sprit-de-corps Proactivity Reliability	- Different inducing IVF were identified in this phase, with emphasis on the efforts by the agents to minimise the lack of human and financial resources (see Discouraging IVF)
	Inducing Value Factors (IVF)	Security Dominance	The same aspects that were identified in the idea generation phase
	Innovation Supporting Factors (Physical Infrastructure for Innovation; Commitment of senior management; Organisational structure; Key Individuals; Continuous individual development; Extensive communication; Teamwork; Learning with the environment; and People management)	Encouraging	- High level of commitment by the Forces' senior management: in 2017, when a specific item was created in the Annual Budget Law for the development of the RDS-Defence programme - Suitable laboratories and infrastructure were made available for R&D activities - Learning with the environment was particularly noticeable in the teams adaptation to the R&D activities and in the creation of manuals to improve the efficiency of the knowledge management process
		Discouraging	Factors related to human resource management: - Experienced staff was not available for technical R&D activities because they were assigned to administrative activities - High turnover of qualified staff and - Lack of human resources to carry out bureaucratic tasks Obs.: these factors suggest that Senior Management should investigate measures that might minimise the difficulties that could hinder the development of the project.