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Creativity: The "Backbone" of Effective Wargaming

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> The general staff officer [...] is a renovator and a creator. They must fight against conservatism, becoming permeable to new ideas so that they can escape crystallization, conformism, and routine.
> *Marshal Castello Branco* (SANTOS, 2004, our translation).

The quote from Marshal Castello Branco has inspired generations of Brazilian Army leaders to act in the face of the unexpected. An old army saying goes, "No plan ever survives the first shot of combat." It is an old saying because it is true. Such surprises during execution are known in US Army doctrine as exceptional information: threats or opportunities that had not been anticipated (UNITED STATES, 2022). Exceptional information is at the heart of this truism, demanding leaders to be able to take the initiative in the absence of orders. One might ask, how can a leader determine, in the heat of battle, what is the appropriate action to take? This idea is central to the mission command philosophy. Leaders on the frontlines must have the imagination to take the next step to meet the commander's, intent as if the commander would visualize it if present. This imagination requires creative work, almost as if the leader is role-playing the commander, i.e., acting a part.

A recent exchange between the US Army Command and General Staff College (CGSC) and Escola de Comando e Estado-Maior do Exército (ECEME) promoted discussions and practices on wargaming, and plans were made for the development of wargaming-focused curriculum. Wargaming is an effective method for testing plans to discover what might make them fail. Wargaming requires imagination, foresight, and prediction—in short, creativity. This creativity is a key skill required for effective wargaming. Therefore, how can we as leaders become more creative and, thus, better wargamers? We at CGSC believe we have answered this question.

In the summer of 2022, a mixed methods experiment was conducted at the CGSC Satellite Campus in Fort Belvoir, Virginia, and at the main campus in Fort Leavenworth, Kansas. A total of 254 students participated in the study. The test group took a two-hour experimental creativity lesson designed to stimulate the creativity centers of the brain through the science of narrative storytelling. The control group participated in a two-hour creativity lesson designed to discuss the concepts of creative thinking. In all instances, the test group outperformed the control group, showing a greater improvement in creativity. To apply a metaphor, the test group demonstrated a 14-point increase in effective intelligence quotient (IQ) at solving complex, open-ended problems under a time constraint. For example, in a group of 14 students, the researchers observed an increase of nearly 20% in creativity (Table 1). One may ask, how can this creativity be useful during wargaming? Considering that creativity is crucial for effective wargaming, we invented a way to enhance creativity.

Table 1 – Initial finding of the isolated test group with 14 participants

14 Participant Isolated Test Group initial finding

Admin #	Pre-Test				Post-Test				% Change
	Novelty	Suitability	Feasibility	All Mean	Novelty	Suitability	Feasibility	All Mean	
2077	3.25	3.25	3.25	3.25	3.50	3.75	3.75	3.67	12.82%
3197	1.25	1.25	1.00	1.17	2.50	2.50	2.50	2.50	114.29%
3314	5.00	4.75	4.50	4.75	6.00	5.00	5.75	5.58	17.54%
3711	3.75	4.25	4.25	4.08	4.75	4.50	4.75	4.67	14.29%
3903	3.50	4.25	4.25	4.00	4.75	4.25	4.75	4.58	14.58%
4076	3.75	4.25	4.00	4.00	4.50	4.50	4.75	4.58	14.58%
4161	3.75	3.75	4.00	3.83	3.75	4.00	4.25	4.00	4.35%
4481	3.50	3.75	3.75	3.67	4.00	3.75	4.50	4.08	11.36%
4872	4.50	4.25	4.75	4.50	5.00	4.75	5.00	4.92	9.26%
6887	5.00	5.00	4.75	4.92	5.75	4.75	5.75	5.42	10.17%
7700	3.75	4.00	4.00	3.92	4.75	4.25	4.75	4.58	17.02%
8445	3.75	3.50	3.25	3.50	5.00	3.25	2.75	3.67	4.76%
8960	3.25	4.00	4.00	3.75	4.75	4.50	4.50	4.58	22.22%
9001	5.00	4.50	4.25	4.58	5.50	4.75	4.25	4.83	5.45%
								Avg Change:	19.48%

So what: Results indicate an improvement in creative thinking when participating in Narrative Practice
Average improvement: 19.48%

Source: table prepared by the authors, 2023

Some leaders might ask, how can I get in on this? What is next for the study of creativity and how can we get tools to improve creativity for ourselves and the soldiers we lead? We are glad you asked.

First, this experimental lesson is being piloted at CGSC in this coming academic year. Further research will be conducted to establish its level of effectiveness in the academic year 2024. Therefore, more information will be shared as a result of this pilot study. Second, the findings of this study are being disseminated throughout the Army University and beyond. For example, two videos were posted on the CGSC YouTube channel (CREATIVITY STUDY..., 2023) with more information on the findings of this study for those who want it.

The research report on the creativity study was published in March (MCCONNELL et al., 2023) and a summary article with the details of this study should be available in June 2023 (MCCONNELL; BENVENISTE, 2023). Finally, those who want to start improving their creativity immediately can try the *Creativity Field Guide*, which offers 30 simple drills designed to enhance creativity (FLETCHER, 2021). The *Creativity Field Guide* drills could easily be incorporated into unit training or classroom instruction in Professional Military Education (PME) without taking up too much time (most drills require 15 to 30 minutes). Enhanced creativity could be at your fingertips, all you have to do is give it a try. Some leaders might ask why is creativity so important for wargaming and what effect could it have during the execution of plans?

Imagine if you were leading soldiers as a Ukrainian military leader right now. Just look at the Ukrainian/Russian conflict and see the combat multiplier that creativity has proven itself to be. In the case of the Ukrainian Army, a smaller force is punching above its weight thanks to creativity. A smaller creative force seems to replicate more combat power and capabilities than a larger, less creative force. In the future, creativity will no longer be an option, but a requirement.

Fortunately for the Brazilian Army, their leaders are some of society's most creative thinkers. At ECEME, an institution that prepares future leaders of the Brazilian Army, field grade officers are encouraged to solve complex and unprecedent military problems. Think about it: how many times have leaders had to adapt to creatively fix problems that they had not anticipated for when they got up that morning? For example, did the Brazilian military leaders who led the army in facilitating security at the 2016 Olympics or in the humanitarian operations at the border with Venezuela since 2018 foresee it before they had to do it? Probably not, but they did it anyway. Brazilian Army leaders are already creative. This research can only make them more creative. Considering what we are observing in Ukraine, if you could make yourself and your soldiers more creative, why would you not? If you could provide your senior leaders with more creative, innovative, novel, and surprising solutions that could help them anticipate what is coming next and seize the initiative from the enemy, why would you not do it? If you were more creative, how might that improve wargaming? The findings of the creativity study will result in tools that Brazilian Army leaders can take off the shelf and use in the field to improve not only operations, but also the thinking that underpins the planning of those operations. We invite you to give it a try.

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The Colombian Defense Doctrine evolution, the Western interference and the adjustments of the internal dynamics

La evolución de la doctrina de defensa en Colombia, la injerencia del Occidente y los ajustes de la dinámica interna

Abstract: Although the Colombian Military Forces (CMF) have historically developed their doctrine following the example of Western countries, the country's history shows how, since the beginning of the military organization, its doctrine has had to change and be adapted to local reality. The CMF Doctrine have acquired differential characteristics, such as the mixed role between the military and the civilian since the times of the Conquest, the policialization of the military and vice-versa, which are intrinsically linked to the development of their functions within the territory. The role of the Colombian Military Forces continues to be mainly internal to counteract the country's security problems; it has been focused on the integrity of the territory and human security in all its dimensions. Despite not being an expeditionary force, the experience and current capabilities of this organization allow their interoperability, which has been focused on peacekeeping operations.

Keywords: Doctrine, Policialisation, Internal Security, Human Security, Interoperability, Peacekeeping Operations.

Resumen: Aunque las Fuerzas Militares de Colombia históricamente han desarrollado su doctrina siguiendo el ejemplo de países occidentales, la historia del país muestra cómo desde los comienzos de la organización militar su doctrina ha tenido que cambiar y amoldarse a la realidad local. Adquirió características diferenciales como el papel mesclado entre el militar y el civil desde los tiempos de la Conquista, y la policialización del ente militar y viceversa, que está intrínsecamente ligada al desarrollo de sus funciones al interior del territorio. La función de las Fuerzas Militares de Colombia sigue siendo principalmente interna, en aras de contrarrestar la problemática de seguridad del país y ha sido enfocada en la integridad del territorio y la seguridad humana en todas sus dimensiones. A pesar de no ser expedicionaria, la experiencia y capacidades actuales de esta organización le permiten una interoperabilidad, que hasta el momento ha sido enfocada en operaciones de paz.

Palabras clave: Doctrina, Policialización, seguridad interna, seguridad humana, interoperabilidad, operaciones de paz.

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1 INTRODUCTION

This article investigates the Doctrine of the Colombian Army, which is theoretically based on doctrines of Western countries, such as the examples used in the framework theories of Huntington and Janowitz about the military profession in the United States and Germany, characterized by being developed under the precepts of expeditionary forces and regular warfare. However, the reality of Colombia has meant that, since the very emergence of the military organization, this doctrine had to be constantly adjusted. In this sense, this article gathers qualitative information from relevant documents regarding the development of the Colombian Army Doctrine to describe historically how, from the time of the Conquest until the latest update in 2018, its development gave rise to its distinctive features.

Military doctrine is understood as the framework that rules what concerns the military forces, characteristics of the profession, its structure, the tasks it performs, and how they should develop from the strategic to the tactical level. Since this framework is logically derived from the State objectives, the Defense Doctrine results from the synergy between political strategy and how, through security, guarantee that this strategy is fulfilled (AVANT, 1993; CALA, 2018; CARDONA-ANGARITA, 2020; PADILLA CEPEDA, 2014; POSEN, 1984a; ROJAS GUEVARA, 2017b).

Academics such as Huntington (1957) in his work "The soldier and the state", and Janowitz with "The professional soldier", published in 1960, developed their theories in which they framed the characteristics of the military profession and its doctrine, based on examples from Western countries such as the United States and Germany, which are characterized by expeditionary forces and in a regular war environment. Huntington and Janowitz described the military institution and its characteristics, both in form and concept. These theories long became the benchmark for the development of the professionalization of other military forces.

Further, academics such as Weiss y Campbell (1991), Avant (1994), Desch, (1998), Fishel (2000), Cohen (2006), Caforio y Nuciari (2006), Charles Bruneau y Tollefson (2014) added components to these theories that allowed adjusting to the circumstances of the reality in which the Military Forces of other countries were developed. They have mainly added that the military also perform duties related to irregular warfare such as counter-terrorism, humanitarian assistance, urban security and peacekeeping operations (CHARLES BRUNEAU; TOLLEFSON, 2014; MADIWALE; VIRK, 2011; MARTÍNEZ; DURÁN, 2017; VENNESSON, 2003; WEISS, 1999). Other scholars such as Lieuwen (1961), Ruhl (1981), Guy (1989), Diamont y Plattner (1996), Sarigil (2011), studied military characteristics specifically for Latin American countries. Due to this Westernization of theories, as well as of those by Huntington and Janowitz, authors such as Arlene Tickner (2003), Sotomayor Velázquez (2004), Acharya and Buzan (2009), Tickner and Blaney (2013) argue that it is necessary to adjust Western theories, in general, to the realities of the non-Western countries where they are applied.

This is the case of Colombia's Defense Doctrine, inherited from the West and which, due to the country's historical development and realities such as the internal conflict since the 1960s, had to undergo transformations to meet its own needs. This doctrine is focused on addressing the country's internal security regarding the basic needs of the population; in other words, irregular warfare, to counter insurgent groups, terrorist attacks and transnational crime.

It is also intended to defend human security, providing humanitarian assistance, urban security and participating in peacekeeping operations.

In this sense, this article hypothesizes that despite its Western roots, the Colombian Doctrine has been adjusted to the country's reality over time. To this end, this article first traces the history of the Colombia's Military Forces constitution, showing from which countries it has acquired doctrine and how it has transformed it according to its needs up to the present day. Secondly, it presents an X-ray of the current Defense Doctrine and finally concludes that, although Colombia's military doctrine has counted on Western contributions, it works only because it has been adjusted to the reality of Colombia's dynamics. This dynamic gives it distinctive characteristics that have led it to become an example for Western countries and organizations such as the United States and the North Atlantic Treaty organization (NATO).

2 THE HISTORY OF COLOMBIA IN THE LIGHT OF THE MILITARY DOCTRINE DEVELOPMENT

In Colombia, the Military Forces constitution dates back to the time of the Conquest in the late 1400s; its roots can be traced back to the Spanish military structures conquered the territory where the country was later constituted. In order to expand into the newly discovered continents, the Spanish Crown offered Spaniards with money to build expeditionary forces to conquer "*Las Indias*" and then settle in exchange for tribute. To that, they appointed Captains or Governors of the expeditionary groups who did not necessarily have military training, and who came from different social backgrounds. These men had to pay the Captains for embarking as well as for their weapons and food. In *Las Indias*, the task of conquering was not very difficult, because, although numerous, the inhabitants of that territory - the Indians - were not experienced in advanced combat techniques or weapons such as gunpowder, swords, armor, or means such as horses or dogs (SANTOS PICO, 2007).

The stage of occupying these territories involved the use of armed force; the conquistadors received from the Spanish Crown the ranks of Admiral, Viceroy or Governor, and the members of their groups began to identify themselves as soldiers. This structure represents the beginning of the military forces and prevailed throughout the Conquest (VALENCIA TOVAR, 1993).

By the 16th century, as part of the agreements between Spain and the conquistadors, capitulations were established. These were extensions of territory where each investor in the Conquest became the Governor-Captain, and was allowed to recruit soldiers and earn money in exchange for tribute to the Crown (VALENCIA TOVAR, 1993). After the conquest, the organization allowed soldiers to become landowners and was named *Encomienda*. Each *encomendero* was granted land and a number of Indians between 500 and approximately 2,000. Their mission was to convert the Indians to Catholicism and recruit them. They were under the orders of the Governor-Captains or Viceroys (VALENCIA TOVAR, 1993). The most relevant characteristic of that period as a foundation for the military forces is that the civilian investors and those who had joined their groups gave them military ranks, so they acted as military individuals with the duty of governing. This dynamic interfered with the conception of the Doctrine since the military tasks were both security and State administration.

Between 1600 and 1700, the new territory called New Granada was administered through the figure of a Military Presidency. Marshal Don Juan de Borja was the first one nominated by the Crown (SANTOS PICO, 2007). In this way, the figure of a military ruler performing civilian roles continued during these periods. By 1718, due to the importance of the territory and the fact that it was constantly under attack, the Bourbon kings transformed it into the New Kingdom of Granada; this status was crucial to shape a more stable and strengthened military organization. In the mid-1700, Charles III made far-reaching reforms to the military forces, strengthening them in terms of men, weapons and fleets of ships to confront the forces of other countries that wanted to occupy the territory (VALENCIA TOVAR, 1993). Towards the end of the century, the then regent Archbishop Antonio Caballero y Góngora restructured and strengthened the military organization once again, as he believed that a tax regime could not survive without the support of a solid military force. To this end, he strengthened points of the State other than Cartagena, the center of government at the time (VALENCIA TOVAR, 1993).

The following period was the pre-independence period, which brought new doctrinal elements. At that time, Spain was fighting France to defend its territory, while the troops in the colony, made up of Spaniards and Creoles, were influenced by the ideas of the French Enlightenment to get emancipated, and were supported by the British. Likewise, the Spanish Crown received the British general Sir Arthur Wellesley to reorganize and train its troops (SANTOS PICO, 2007). The Colony's troops were organized in the same way as the Spanish ones, been preserved to this day. Table 1 shows a comparative example of the organization of the Spanish Army of the time and the Colombian Army as of 2022.

Table 1 – Comparison of the pre-independence Spanish Army and the 2022 Colombian Army

Comparison of the pre-independence Spanish Army and the 2022 Colombian Army	
Pre-Independence Spanish Army	**Pre-Independence Spanish Army**
Captain General	Non-existent
Lieutenant Colonel	General
Marshal	Major General
Brigadier	Brigadier General
Colonel	Colonel Full
Lieutenant Colonel	Lieutenant Colonel
Chief	Commander
Captain	Captain
Lieutenant	Lieutenant
Second Lieutenant	Warrant Officer
Major Sergeant	Major Sergeant
Second Sergeant, Vice Sergeant, First Sergeant	Second Sergeant, First Sergeant
Second Cable, First Cable	First Cable, Second Cable
Soldier	Soldier

Source: VALENCIA TOVAR, 1993, p. 73

This comparative table is relevant in the sense that it shows how the Colombian military organization from the pre-independence period keeps its Western roots, here from Spain.

Then during Independence, proclaimed on 20 July 1810, which did not become effective immediately, but only nine years later through the Battle of Boyacá, and then 14 more years until the final Battle of Ayacucho. During this period of insurrection, the military institution was characterized as improvised, mostly made up by Creoles and natives from the middle and lower classes. This period is considered the starting point of the Colombian military forces and their schools (CARDONA-ANGARITA, 2020).

The next period is the Republic, and is mainly characterized by the organization of the militias and the creation of the National Guard Volunteer Battalion, which in addition to Creole soldiers also included Spanish soldiers who swore allegiance to the new Republic. Lieutenant Colonel Antonio Baraya was appointed Commander, and this unit is historically considered the first army of Colombia (SANTOS PICO, 2007). Another event that characterizes the organization by that time is the presence of Simón Bolívar, who arrived in Cartagena in 1812 and not only became a leader, but also brought to military doctrine the lessons learned from his studies in Spain, France and Great Britain. For Bolívar, war should be conducted under the offensive principle in order to protect the territory. He also contributed his political vision through the Cartagena Manifestos, in which he set out his centralist political ideal and the damage caused by Federalism to the Republic (MARTÍNEZ et al., 2019). That period makes evident the military interference in political thought between centralism and federalism; in fact, political parties in Colombia were born from the military, following these two guidelines (VALENCIA TOVAR, 1993). Likewise, in that period Bolívar reaffirmed the dual function of the military as defenders and administrators of the territory, a military and political function that had been maintained since the Conquest.

Subsequently, other relevant military leaders appeared, such as Francisco José de Caldas, who contributed to military thought by conceptualizing the subjective values of military virtues such as the soldier's glory, courage, obedience, moderation, the value of truth and love for the Homeland. For Caldas, the main virtue of a soldier is military honor (SANTOS PICO, 2007).

That period was also influenced by other European officers who contributed to the cause of independence. For example, Antonio Nariño, a politician and military man who translated the rights of man from France to defend Cundinamarca, counted on the collaboration of the French officer Antonio Bailly. Another Frenchman who contributed at the time was Manuel Roergaz De Serviez, an instructor who brought with him the doctrine of the places where he had previously served, such as England and Prussia (VALENCIA TOVAR, 1993). These contributions are relevant to this article, because they display the Western currents, and how the pattern of combination between military-political (like Bolívar) or political-military (like Nariño) continues.

As the Republic administration was decentralized, the military organization also resulted in a disconnection between the Provinces, which allowed Spain to reconquer it. The Spanish officer in charge of this task was Pablo Morillo, and at the time it was labelled as the "regime of terror, due to the violence inflicted by this military officer and his subordinates, to successfully reconquest it" (MARTÍNEZ et al., 2019, p. 45; SANTOS PICO, 2007, p. 88, free translation). This violent era gave rise to the first subversive movements fighting again for freedom. An interesting characteristic

is that these groups that emerged around the territory were supported by the civil and ecclesiastical authorities, as well as society at all levels (VALENCIA TOVAR, 1993).

Bolívar returned to New Granada and began his Liberation Campaign in 1819. He gathered the remaining troops of New Granada, the subversive groups that had been formed, used the support of the people for logistics, and asked for help from the British Legion. Other nationalities were also present in these mixed troops, such as Poles, French and Italians (MARTÍNEZ et al., 2019).

Bolívar won the victory and all the Commanders who had accompanied him in the battles for independence were appointed Governors of the provinces. Francisco de Paula Santander was appointed Vice-President, and this was seminal not only for the military organization, but also for constructing the State, because he started organizing the laws and promoted education. At that time, the military forces left their Spanish doctrine and switched to the French one, which governed them throughout the 14th century (MARTÍNEZ et al., 2019; ROJAS GUEVARA, 2017a). It is valuable for the argument of this article that, regardless of the doctrine followed by the military of the time, whether Spanish, French or British, the military organization was also adjusted to govern and create the Nation State.

The Republic consolidation is characterized by a series of civil wars entailing from a permanent dispute between Federalism and Centralism. This caused the military institution to flip over its doctrine to counteract the internal problems. The institution was in constant reorganization to effectively consolidate the State. These characteristics that have been maintained to this day (GÓMEZ, 2016; MARTÍNEZ et al., 2019).

By 1830 the territory continued to be reorganized; some provinces separated, others united, and what had become Gran Colombia was dissolved. The Republic of New Granada and a Constitution appeared, becoming crucial to the military forces that had been reorganized. A regular Army and a National Guard were established, as well as conscription for men of 18 to 36 years old. The National Guard was constituted as a complementary body to the Army, and was composed of volunteer civilians who wore the uniform and supported public order issues (CEBALLOS GÓMEZ, 2011; ESQUIVEL TRIANA, 2009; LA ROSA; MEJÍA, 2017).

Paradoxically, Santander as president (1832-1837), after all this time the government was in the hands of the Military, withdrew almost all support for the troops and removed them from the political arena. However, throughout the 19th century, the Military continued to take on political positions, while the landowners took military positions. This relationship between landowners and the military power affected civil wars since soldiers were forced by their landowner to fight in defense of their political affiliation (Federalist or Centralist). This dynamic of bipartisan wars caused the decline of the military doctrine (BARRIGA, 1852; PINZÓN, 1856).

As civil wars went on, each passing government weakened the military organization. Some reduced its budget and pension, such as General José María Obando (1853-1854), while others reduced the troops, such as Manuel María Mallarino (1855-1857). The central Army was reduced to such an extent that they suffered defeats, and landowners began to build private armies (ATEHORTÚA, 2001; CEBALLOS GÓMEZ, 2011; PLAZAS OLARTE, 1993; SANCLEMENTE, 1858).

In the following period - from 1863 to 1865 - the United States of Colombia was formed. In 1863 a new Constitution was established, and continued the weakening of the

military. Three different corps were created: the Gendarmerie that was like the Police; the Municipal Guard that had the roles of infantry, cavalry and artillery; and, finally, the Civilian Companies that were in charge of public order issues. Military training was provided only if necessary and the service was voluntary (MARTÍNEZ et al., 2019).

This era of doctrinal structural weakening of the military force ended in 1886 with the arrival of President Rafael Núñez, who ruled three times (1880-1882, 1884-1886, 1887-1888). Núñez was valuable the Republic and the military forces because he created the 1886 Constitution that remained in force until 1991. Through the Constitution, he introduced centralized government, established a permanent Public Force, called the National Army and the National Police, and determined that all citizens were obliged to take up arms to defend the Nation (ATEHORTÚA, 2001; GONZÁLES, 2006).

From this moment on, starts a new era in the evolution of the military forces for the defense of the country. For the sake of professionalization, President Núñez brought a series of military missions from different countries to contribute to modernization from France. Such missions came from the United States and Chile (ATEHORTÚA, 2001; PINZÓN BUENO; RODRÍGUEZ URIBE, 2016) However, discussions between political parties continued to affect the military profession, since politicians continued to interfere, for example, in issues such as promotions that which were granted based on political affiliation (GONZÁLEZ; BETANCOURT MONTOYA, 2018; MARTÍNEZ et al., 2019). This modernization process was also influenced by the fact that, being in peacetime, the tasks of the military were more policeized[1] and military training was scarce (MARTÍNEZ et al., 2019; PINZÓN BUENO; RODRÍGUEZ URIBE, 2016). The policeization of the Military Forces and the militarization of the Police in Colombia are traits that emerged from the beginning of the organizations, and have been maintained to this day. The military not only work within the country, but also secures urban and rural areas, and contributes to citizen security.

Then came the Republican period, accompanied by another injection of modernization for the military forces. President Rafael Reyes (1904-1909), who led the country in a period of post-civil wars and calm, considered the military forces essential for internal stabilization and to guarantee state sovereignty. In this sense, Reyes elaborated a statute in which he gave the State the monopoly of arms, through its military force, and increased military education through academies. For example, the Naval School was created. He also defined that the military should be in favor of the State and not of any party affiliation, and designated Battalions for the construction of infrastructure and other works to cover the basic needs of the population (ATEHORTÚA, 2001, 2009; PEÑA, 2016; SANTOS PICO, 2007). In order to continue with the modernization of the military forces, Reyes appointed General Rafael Uribe as his Minister of War. General Uribe brought other military missions from Peru and Chile. Modernization included compulsory military service, a State-funded reserve system, the War College was organized, the chain of command, the General Staff, the Military Health service, and the Army was given a Divisionary organization (ARANCIBIA CLAVEL, 2002; ATEHORTÚA, 2001; CAMACHO ARANGO, 2016; CARDONA-ANGARITA, 2020; PADILLA CEPEDA, 2014; PIZARRO, 2018; ROJAS GUEVARA, 2017a).

1 The term "policialization" defined by Salazar (2009, p. 11) is used to refer to the assignment of police tasks to the military, but police militarization can also occur.

At the end of the military missions that extended until 1929, the military forces achieved changes that shaped them into what they are today: centralized, with coverage in the national territory, an established line of command, and focused on tasks to counter internal problems. In addition to this, in the 1930s other events took place that helped to further demarcate the organization. In the first place, Enrique Olaya Herrera (1930-1934) as the first president of the Liberal party after 44 years of conservative governments, decided that the military should be apolitical; to that, he prohibited members of the Military Forces and the National Police from voting, a decision that is maintained to this day (ATEHORTÚA, 2001). On the other hand, during that period the Army was charged with making its presence felt and developing remote areas of the country through military colonies. These were towns founded by the military and their families, especially in the departments of Caquetá, Amazonas and Putumayo. To that, they built roads that communicated with the center of the country, helped improve the navigability of rivers, taught indigenous communities to read and write, and established defense points. In short, they were assigned the task of developing and building a Nation State (MARTÍNEZ et al.,2019). Liberal guerrilla groups also emerged in that decade because of disagreements over land distribution and more than four decades of conservative governments. Between 1932-1933 Peru invaded the Colombian territory, leading to a war (ÁLVAREZ ESTRADA, 2015; MARTÍNEZ et al., 2019; PIZARRO, 2018). On the one hand, the war with Peru unveiled the need for adequate armament, air and naval capacity. The emergence of guerrilla groups set the trend in counterinsurgency doctrine and stabilization of public security.

In the following decades, in the second mandate of Alfonso López Pumarejo (1934-1938 and 1942-1945), he removed several Generals from office so that they would not interfere in politics, and reduced the troops. In opposition, he appointed a General as Minister of War - an office traditionally held by a civilian (ATEHORTÚA, 2001). In the following mandate of Mariano Ospina Pérez (1946-1950), due to outbreaks of violence throughout the country, he decided to appoint military persons as mayors and governors in more than 200 cities and municipalities (ATEHORTÚA, 2001) During both governments and in those decades in general, the military continued to fulfill other roles in government or governing. This practice, as we have seen during the development of this article, was born from the very moment of the conquest. Although the Colombian Army has developed based on the Western doctrine, it has its own characteristics such as this mix of military and political roles.

Another event that marks the military doctrine in Colombia is its participation in the Korean War (1950-1953), where experiences in organization and counterinsurgency were gathered, mainly from the United States. Some Colombian Military Officers such as Álvaro Valencia Tobar and Alberto Ruiz Novoa understand that the U.S. military organization, its advantages and also how relations with the civilian population help in the counterinsurgency fight, the fact of winning minds and hearts and the advantages it provides in war (CARDONA-ANGARITA, 2020; GARCÍA, 2003; LEAL BUITRAGO, 2002; MELÉNDEZ CAMARGO, 2015; ROJAS GUEVARA, 2017; SANTOS PICO, 2007; SILVA *et al*., 2018; VALENCIA TOVAR, 1993). The author, however, considers it relevant to highlight that, although these lessons learned from Korea have caused the formal inclusion of the theme of "winning minds and hearts" into the Doctrine, history shows that the role of meeting the basic needs of the population has been inherent in the Colombian Military Forces since their beginnings.

The second half of 1900 begins with the military government of Rojas Pinilla (1953-1957), seminal for several reasons: unlike the trend in the subcontinent of civilian and military dictatorships, in Colombia, due to the discrepancies between the Liberal and Conservative parties, these parties decided to hand over the power to the military, headed by General Rojas Pinilla, to cease violence. During this mandate, the church and civilians did not lose political participation and, in doctrinal terms, although the military forces "were governing", they stopped supporting political parties and began to support the government and devote themselves to their public order function (DE MONCADA, 2007; RAMÍREZ, 2001; VALENCIA TOVAR; GARCÍA, 2003).

This government ended with the birth of the National Front, an agreement of the political parties to share power alternating every four years. The first President of this agreement was Alberto Lleras Camargo (1958-1962), who in a speech at the *Teatro Patria* on May 9, 1958 expressed that the military should concentrate on managing the war, and the politicians on politics. According to Pizarro (2018), this speech caused the "divorce" between the military and politicians in the country. Since then, the civilians of the Colombian elite believed that internal order was the responsibility exclusively of the security forces. This disconnect caused the weakening in the fight against the guerrillas, and the military ended up performing tasks that were the primary responsibility of other government entities, such as education and health (ATEHORTÚA, 2001; BRUNEAU; GOETZE JR., 2019; LEAL BUITRAGO, 2002; PIZARRO, 2018; VALENCIA TOVAR; GARCÍA, 2003).

The next government was that of Guillermo León Valencia (1962-1966), significant for military doctrine since he appointed Alberto Ruiz Novoa, who had participated in the Korean War, as Minister of War, along with other military staff such as Álvaro Valencia Tovar and Gabriel Puyana. These military officers were called the *Desarrollistas*, and with the knowledge brought from Korea they contributed to the modernization of the Army (LEAL BUITRAGO, 2002; PIZARRO, 2018). The 1960s had other relevant characteristics in the security dynamics in Colombia, which marked the path of doctrinal development until today, such as the birth of the guerrillas of the Revolutionary Armed Forces (Farc), the National Liberation Army (ELN) and the People's Liberation Army (EPL), added with the increase in marijuana and coca crops. In order to fight these crimes, Minister Ruiz Novoa created the *Plan Laso*, a military strategy to integrate military activities with society, contribute to the country's development and avoid Communism (ATEHORTÚA, 2001; COMANDO...,1962; LEAL BUITRAGO, 2002; SANTOS PICO, 2007).

Between 1960 and 1970, several decrees were issued (1963, 1968 and 1974) that contributed to the increase in military salaries, special bonuses and concessions in the pension system Likewise, in the 1970s the United States allocated an aid budget to Latin American military forces for training and equipment, and 10% of that budget went to Colombia(ATEHORTÚA, 2001).

In the 1980s, the military doctrine was focused, on the one hand, on counterinsurgency in rural and urban areas, as guerrilla violence intensified through terrorism such as the attack on the Palace of Justice in 1985. Drug cartels were also involved in the attack, supporting it with money to prevent their extradition. On the other hand, the military began their participation in peacekeeping operations. In 1982 they were assigned to the Multinational Observer Force intended to maintain the peace treaty between Egypt and Israel, participation that remains until today (BRUNEAU; GOETZE JR., 2019; MARTÍNEZ *et al*., 2019).

In the 1990s the violence of guerrillas and drug cartels continued. Security was completely deteriorated, to the point that citizens could not move within the country, foreign investment declined, Colombia became a failed State. The Army suffered the greatest operational setbacks, such as the FARC attack on the *Las Delicias* base, which resulted in the death of 27 soldiers and the kidnapping of 60 other ones. During the Presidency of Andrés Pastrana (1998-2002), the government begins peace negotiations with the Farc, without success as this group continued attacking the population. President Pastrana then ordered the military forces to reoccupy the territory that had been set aside by the government for these talks. As a result of all these events, from 1999 to 2006 the military forces had to undergo a transformation to overcome this security issue. Modernization focused on training, doctrine revision, campaign strategies, and increased skills. All that together with international cooperation, as the drug problem is transnational (BRUNEAU; GOETZE JR., 2019; MARTÍNEZ *et al*., 2019; PINZÓN, 2016; PIZARRO, 2018; ROJAS GUEVARA, 2017a).

In this regard, the U.S. government approved a cooperation package to fight drug trafficking. This aid was delivered through the *Plan Colombia* in which there were contributions from the USA and Colombia (BRUNEAU; GOETZE JR., 2019; GONZÁLEZ; BETANCOURT MONTOYA, 2018; PADILLA CEPEDA, 2014; PINZÓN, 2016; PIZARRO, 2018). The Plan allowed the reengineering of the military forces as regards equipment and training, and also meant a contribution to doctrine, for example, in the rotary wing and fixed wing field. However, the doctrinal contribution of the United States was adjusted to the Colombian operational needs.

Between 2002 and 2006, the first government of President Álvaro Uribe created the Democratic Security Policy, focused on the consolidation of the territory, protection of the population, elimination of drug trafficking, and maintenance of the strategic deterrent capacity, which served as a new impulse for the modernization of the military forces. The defense tax was reinforced, enabling advances such as the expansion of troops, improvement in training and equipment, an increase in salary, creation of military units, and the strengthening of Army aviation (BRUNEAU; GOETZE JR., 2019; PIZARRO, 2018; SANTOS PICO, 2007).

In doctrinal terms, this evolution provided flexibility to the Army, greater mobility, increased intelligence capabilities to achieve a meaningful understanding of the nature and purpose of the enemy, aiming at their disarmament and demobilization (PIZARRO, 2018). This boost to the military forces served for them to gradually gain control of the territory, recovering security and investment. The doctrine was strengthened in joint operations, boosting the coordination between the Army, Navy and Air Force, added to inter-institutional cooperation, aligning the military and political objectives (PINZÓN, 2016; PIZARRO, 2018; SANTOS PICO, 2007).

The *Consolidation Plan* was created for the military and other government entities to be present in remote areas of the country. This coordination was through the use of the Doctrine of Integral Action focused on the protection of the civilian population and their basic needs. The Integral Action, vital to create stable conditions for the consolidation of territorial control, won the "minds and hearts" by improving the logistical skills of the military forces, and teaching the ability to build, for example, highways, bridges and parks. The Colombian experience in this civil-military doctrine has been studied by organizations such as NATO,

and constitutes a case study with lessons learned that can be used by other countries in armed conflict (PINZÓN, 2016; PIZARRO, 2018). That Action is a particular characteristic of the Colombian military doctrine.

These doctrinal changes allowed the military forces to subdue the guerrilla groups. After 2010, the door was opened to the next government to negotiate peace agreements with the Farc (BRUNEAU; GOETZE JR., 2019; PIZARRO, 2018). In 2011, the Ministry of Defense created a strategy for the reengineering of the military forces, establishing the Strategic Review and Innovation Committees (Crei). The objective of this restructuring was to achieve visible, decisive, lethal, integrated, interoperable military forces to fulfill multi-missions in response to any threat. Also, structural changes in organization, technology, personnel management and doctrine (CASTILLO CASTAÑEDA; NIÑO GONZÁLEZ, 2020; ROJAS GUEVARA, 2017a, 2017b).

The Crei programmed a 3-stage transformation process. The first one from 2014 to 2018 focused on the military offensive, guaranteeing security and defense, and becoming a regional and hemispheric model. The second from 2018 to 2022 focused on interoperability and capabilities aligned to international standards. The third stage from 2022-2030 to achieve a Multi-mission Force, which faces all types of threats related to the Constitution (FERNANDEZ-OSORIO *et al*., 2019; ROJAS GUEVARA, 2017b).

Within this transformation, considering that the peace negotiations would change the dynamics of the internal armed conflict, existing for more than 60 years, and faced with a new situation of a possible post-conflict and the existence of transnational crime, in 2015 the *Minerva Plan* was created for the renewal of the Army doctrine, which was called *Damascus*. This was the latest doctrinal change to the Army, adjusted so that the military maneuver can adapt to the constant changes in the operational environment and attached to more efficiently meet national objectives (CASTILLO CASTAÑEDA; NIÑO GONZÁLEZ, 2020; CIRO GÓMEZ; CORREA HENAO, 2014; FERNANDEZ-OSORIO *et al*., 2019; GONZÁLEZ; BETANCOURT MONTOYA, 2018; SÁNCHEZ *et al*., 2017; SILVA *et al*., 2018).

Finally, a part of this doctrine that for this article is noteworthy are the adjustments made to tasks toward favoring the civilian population, such as the coordination with other governmental entities, and the contributions of civilians to the public security and defense policy (SILVA et al., 2018). According to authors such as Sánchez et al. (2017) and González and Betancourt Montoya (2018), this trend of incorporating human security in its seven dimensions (economic, food, health, environmental, personal, community and political security) has been promoted by the United Nations, among others, since 2009. However, this text disagrees with this argument because, as the history of the doctrine in Colombia shows, human security has always been part of its tasks. What has happened in the doctrine is that guides or more organizations have been added.

3 CONCLUSIONS

This article has described how the Colombian military organization has historically developed its doctrine. It shows that, differently from the framework theories of Huntington and Janowitz in which the military profession and its doctrine are described based on Western examples, the doctrine of the Colombian Army confirms the proposed hypothesis of how, despite

having been created under a Western legacy and continuing to receive Western legacies, up to now it has to adjust to the internal dynamics of the country. This doctrine has differentiating characteristics such as the mix role between the military and the civilian since the times of the Conquest, which has generated a military role practice in the fulfillment of tasks that in principle should be of other governmental institutions. This has also led to the policeization of the military and vice versa, linked to the fact that since its beginnings the military organization has worked in the inlands of the territory. Its function continues to be mainly internal: work on the country's security issues focused on the integrity of the territory and human security in all its dimensions. Despite not being an expeditionary force, the experience and current capabilities of the Colombian Military Forces ensures its interoperability, which has been focused on peacekeeping operations.

Finally, it is necessary to continue researching on the origin and development of the doctrine of military organizations in Latin America, since distinguishing their roots and progress allows understanding their essence and making the right public policy decisions for their operation in balance with the Nation and the international dynamics.

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Support for defense procurement decision: structuring multi-criteria problems using the Analytic Hierarchy Process (AHP)

Ayuda a la decisión sobre adquisiciones de defensa: estructuración de problemas multicriterio con el Proceso de Análisis Jerárquico (AHP)

Abstract: The procurement of products, systems and their defense components presents characteristics that make operational research particularly useful for solving problems about choosing materials for the Armed Forces, including the multi-criteria decision support theory. The problem about defense procurement fits this methodology, as it involves the use of decision criteria for the most satisfactory choice among a finite set of defense products, since the high technology and the large resources required for the production of these systems make the defense market restricted to a few developers and manufacturers. A multi-criteria method widely used in the defense industry is the Analytic Hierarchy Process (AHP), mainly due to its simplicity of validating expert's evaluations. The AHP calculation equations are described here and can be implemented in different pieces of software, including Excel, R, and Python, among others. A simulated application presented how data were collected and the sequence of AHP calculations for a problem about choosing three aircraft, evaluated under six criteria, indicating an expert's order of preference.

Keywords: defense procurement; support for multi-criteria decision; AHP.

Resumen: La adquisición de productos, sistemas y sus componentes de defensa presenta características que hacen que la investigación operativa sea especialmente útil para los problemas en la selección de material para las Fuerzas Armadas, incluyendo la teoría de ayuda a la decisión multicriterio. El problema de las adquisiciones de defensa se ajusta a esta metodología, ya que implica el uso de criterios de decisión para una selección más adecuada entre un conjunto finito de productos de defensa, puesto que la alta tecnología y los grandes recursos necesarios para la fabricación de estos sistemas hacen que el mercado de la industria de defensa esté restringido a algunos pocos desarrolladores y proveedores. Un método multicriterio ampliamente utilizado en el sector de defensa es el Proceso de Análisis Jerárquico (AHP), principalmente debido a su simplicidad de validar las evaluaciones de los especialistas. Aquí se detallan las ecuaciones para el cálculo del AHP, pudiéndose implementar en diferentes softwares, incluyendo Excel, R y Python, entre otros. La aplicación simulada mostró la forma de recolección de datos y la secuencia de cálculos del AHP para un problema de selección de tres aeronaves, evaluadas bajo seis criterios, indicando el orden de preferencia de acuerdo con un especialista.

Palabras clave: adquisición de defensa; ayuda a la decisión multicriterio; AHP.

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1 INTRODUCTION

The procurement of products, systems and their defense components involves complex and multidimensional analysis, in which several technical factors need to be evaluated, such as the adequacy to the gap in defense arsenal capabilities (CORRÊA, 2020; VIANELLO; MARTINS, 2019); the life cycle costs of possible solutions(SOUSA et al., 2021), and the maintenance and modernization capacity of the country's systems, and others (NEGRETE; SOUSA, 2018; PACHECO; PEDONE, 2016). The presence of these different evaluation criteria and a finite set of possible solutions to meet the Armed Forces' needs suggest the use of specific decision support methodologies, capable of offering a technical and satisfactory result.

In general, the process of choosing products, systems and their defense components that suit the Armed Forces' needs can be assisted by operational research methods, which are intended to support decision-making. Mathematical models produce results that give more objectivity to the process, providing a certain isolation in relation to other aspects which also are taking into consideration in decision-making, such as those of a political nature (KRUGER; VERHOEF; PREISER, 2019).

In a certain sense, it is possible to consider that the defense industry portfolio is limited with regard to the options available in the market for off-the-shelf procurement, or even for the generation of a research and development (R&D) project. This industrial sector increasingly depends on high technology, and, then, in order to remain state-of-the-art, there is need of trained human resources and financial amounts, which are restricted to a few developing and manufacturing countries worldwide (ABREU, 2015).Therefore, to deal with this finite set of possible solutions to the problem, operational research provides methodologies generically designated as Multi-criteria Decision Aid (MCDA) methods (ALMEIDA, 2013).

The MCDA methods, instead of seeking an optimal solution to the problem, seek a satisfactory one, because a finite set of possible solutions hardly includes that which presents the best performance in all decision criteria. If a solution with these characteristics is present in the set of possible solutions, there would be no need to model the problem, as the best answer would already be evident to decision makers. In general, the possible alternatives to the problem present irregular performances across criteria, sometimes performing as the best, sometimes as the worst, sometimes as intermediate in relation to the other alternatives. Under these conditions, there is no an optimal solution, but alternatives that are more satisfactory or more acceptable than others (ALMEIDA et al., 2019).

This article deals with the structuring of the essential elements of MCDA methods in problems about the procurement of defense products, their systems or system components. A practical application with the Analytic Hierarchy Process (AHP) is also presented, mainly because it is widely explored in problems about defense procurement (BELL; HOLODNIY; PAVLIN, 2016; BROWNE, 2018; CHO et al., 2022; GAVIÃO et al., 2020; GAVIÃO; DUTRA; KOSTIN, 2021; STERN; GROGAN, 2022).

The AHP presents a simple and intuitive logic, since it explores a specific scale for evaluations and presents an instrument for result validation, giving credibility and confidence to the process. This method was proposed by Thomas Saaty, in the early 1970s, and is widely supported in the scientific literature, with applications in the most varied areas of knowledge (SAATY, 1972; YU et al., 2021).

2 STRUCTURING THE MCDA MODELING

Modeling problems with MCDA methods involves three essential tasks: selecting alternatives to the problem, choosing the decision criteria, and evaluating the performance of each alternative in relation to the chosen criteria. These three elements configure the so-called problem decision matrix. Subsequently, this decision matrix needs to be submitted to some mathematical model to produce the expected result, which may be, for example, the order of preference of the finite set of solutions or the classification of solutions in clusters, among others (POMEROL; BARBA-ROMERO, 2012).

In defense procurement, these essential elements need to be surveyed and evaluated in line with the scenarios of employment of the Armed Forces (KRESS; MORGAN, 2018). Scenario prospecting is not analyzed in this article, despite being an important part of the process of choosing defense products, systems and components. The portfolio of defense products available to the Armed Forces should enable them to be employed in short, medium, and long term scenarios. Indeed, it is fair to assume that the contexts impact the experts' evaluations of the decision matrix, and it is possible that the same criterion or alternative will have different results depending on the situation presented.

2.1 Selection of problem alternatives

A finite set of alternatives capable of solving the problem has to be considered. In practice, these alternatives are defense products, their systems or components that were planned for acquisition or even R&D projects for construction in shipyards, factories and facilities of consortia established for this purpose. In the classic modeling system, it is assumed that the alternatives are different and that they comprise the entire set of decisions, with no possibility of choosing a mixed solution, composed of the union of alternatives or a portion of them. If the decision maker introduces a new alternative, then, in principle, the analysis process should be repeated with the newly formed set of choices (POMEROL; BARBA-ROMERO, 2012).

The set of alternatives should not be trivial, such as a set of only two alternatives where one clearly performs better. On the other hand, the set of alternatives should have a manageable size, avoiding the preliminary choice of dozens or hundreds of possible alternatives. One way to reduce the size of the set of alternatives is to eliminate those that are similar or that are clearly dominated by others. This dominance is characterized by better performance of one alternative in relation to the other in all criteria. Therefore, in this case, it makes no sense to proceed with

the modeling and analysis of some less qualified alternative, which should be excluded from the initial set.

The alternatives considered for analysis have to be feasible as well, in the sense that they are viable from a financial and logistical point of view. It is necessary for the country, its defense industry and its Armed Forces to be able to acquire, operate, maintain, and dispose of the defense product at the end of its life cycle. This requires managerial capacity to structure the integrated logistics of new defense products and society's acquiescence in supporting a defense budget compatible with the life cycle costs of the new means. There are defense products that operate for decades, like some ships and submarines, which require massive resources to maintain them active and modernized for a long period, following the state of the art of other systems. These aspects need to be considered during the survey of the set of alternatives to the problem.

2.2 Choice of decision criteria

Criteria are special problem attributes or characteristics that the decision maker prefers in their choice. In managerial problems, it is common to use criteria related to purchase price, quality, material resistance, product appearance, and maintenance economy, among others. Some criteria are essentially quantitative, and are measured by numerical units and scales (weight, dimensions, and costs), while others are qualitative and measured by preference ordinal scales, which take into account the evaluator's perception rather than results or performances (quality, appearance, and risk).

According to Roy (1985), a criteria family is considered coherent if it satisfies three requirements:

- Integrity: none of the relevant attributes to discriminate the alternatives was forgotten. The full use of the most relevant criteria for searching a solution to the problem would not allow, in theory, the existence of pairs of alternatives having the same score, in such a way that the decision maker can state, without hesitation, the preference ratio between them.
- Consistency: the decision maker's final preferences have to be consistent with the preferences in each criterion. This means that if "a" and "b" are two alternatives between which the decision maker is indifferent, reaching, for example, the same score for each criterion, then the improvement of "a" in one criterion and/or the degradation of "b" in another criterion implies, in fact, that "a" should be preferable to "b" for the decision maker.
- Non-redundancy: two criteria must not be similar in the sense of evaluating the same performance variables. The existence of two or more criteria with this characteristic unbalances decision-making, as a common attribute will have been considered more than once for the result. Special attention must be given to the use of indices for criteria, as they are generally composed of variables that may be common to other criteria. A coherent criteria family that satisfies the integrity

and consistency requirements is not redundant if the removal of a single criterion compromises the remaining set to just these requirements.

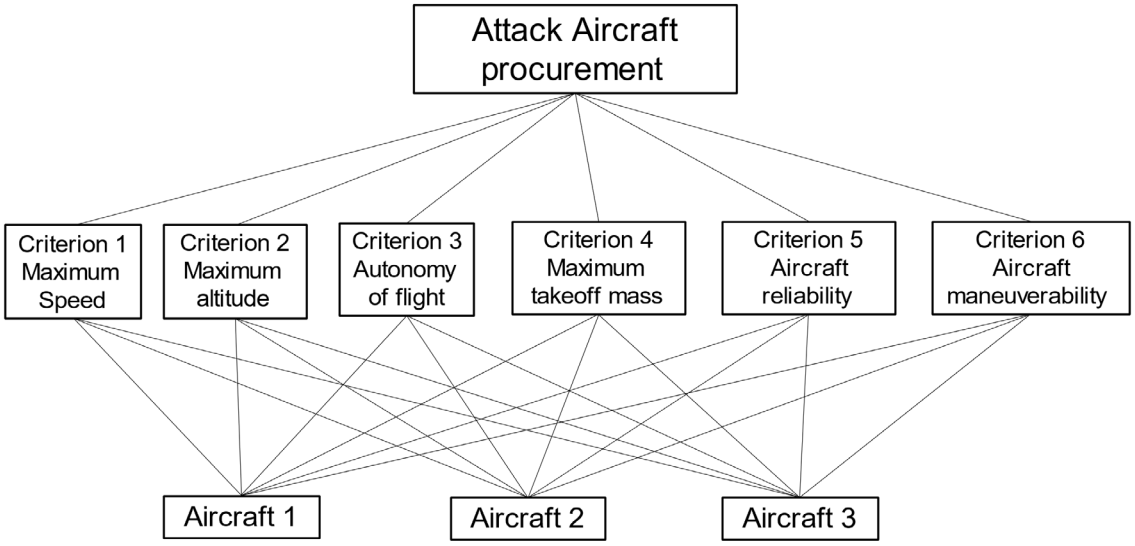
When modeling the problem, Pomerol and Barba-Romero (2012, p. 313) warn that integrity should be the priority requirement when choosing the criteria, as a rational decision maker, experienced and knowing about the problem, tends to select the criteria that should effectively be considered for choosing the most satisfactory alternative. Integrity has a positive impact on the consistency and non-redundancy requirements of the criteria family. Those authors also recommend that the MCDA modeling should avoid a high number of criteria (more than seven), but if this is absolutely necessary, a hierarchical structure should be built at different criteria and sub-criteria levels This comment reinforces the indication of the AHP method, which uses this type of structure to search for the most satisfactory solution.

In problems about procurement of defense products, some criteria are usually explored. Operational performance, for example, is critical to success on the battlefield, whatever the operating environment. For a weapon system, fire accuracy and rate (number of shots per time) are relevant requirements. Another set of important criteria refers to logistics, expressed through reliability and maintainability characteristics. Reliability affects system readiness. The more reliable your components are, the less frequent the breakdowns and the more educed the need to stop for repair services, in addition to reduction in spare parts costs. Such a criterion is quantitative and is usually measured by the mean time between failures (MTBF). Maintainability is an attribute that portrays the ease (or difficulty) of maintaining the system. A modular component that allows maintenance with the help of a plug-and-play system is more sustainable than one that is interconnected by wires, or one that requires the disassembly of system components in order to reach the damaged component. Similar to reliability, the maintenance structure of an item can be measured with the help of the repair and maintenance service time (KRESS; MORGAN, 2018).

Finally, it is also worth highlighting the criteria related to life cycle costs and the risks inherent to R&D projects for a new system. The costs related to future expenditures on the operation and maintenance of the systems are more uncertain than the R&D costs for an item in an advanced stage of development, or the purchase price of an off-the-shelf item. There are pessimistic estimates that operation and support costs can represent more than 80% amount needed for the entire life cycle of a defense product (GAVIÃO et al., 2018). The risk may be related to delays in development and production schedules, or even to rising planned costs, exceeding the desired budget (KRESS; MORGAN, 2018).

In summary, items 2.1 and 2.2 show the essential elements for modeling an MCDA problem and, simultaneously, for building the hierarchical structure for the AHP use. Figure 1 illustrates the hierarchical tree used by Ardil (2021) to choose an attack aircraft. Despite the author's concern about evaluating essentially operational aspects, this structure is sufficient to demonstrate the AHP methodology use, even without applying logistics, reliability, and maintainability criteria.

Figure 1 – Hierarchical structure of a problem



Source: adapted from Ardil (2021)

2.3 Selection of experts

Defense procurement involves a significant portion of government, defense industry, and academic-scientific sectors (GAVIÃO et al., 2020). These sectors bring together the parties interested in the procurement process and are called stakeholders. Because they represent different interests, points of view, agendas and goals, stakeholders are potential experts to be consulted for data collection (SUN et al., 2008). In other words, combatants (the future users of the item) can focus on the effectiveness of the system and its compatibility with the platforms currently used by the Armed Forces. System developers may take a broader view and will be concerned about issues of force structure and other strategic considerations. Technical experts will focus on the scientific aspects of engineering and, in particular, potential technological challenges that may affect the risk criterion. Finally, budget managers will naturally pay a greater attention to programmatic aspects associated with the financial capacity of system development, production, operation, and maintenance. In this context, it is interesting to gather evaluations that cover the stakeholders' areas of knowledge, so that the AHP result reflects a balanced solution in relation to different points of view and interests.

2.4 Performance evaluation

The evaluation of the alternatives in each criterion of Figure 1 allows configuring the problem decision matrix. Each line of the matrix (Figure 2) expresses the performance (a) of the (m) alternatives "A" in relation to the (n) criteria considered "C." Each column presents the evaluations of all the alternatives adopted by the decision maker, relative to a specific criterion.

Figure 2 – Decision matrix

$$\begin{array}{c} \\ A_1 \\ \vdots \\ A_m \end{array} \begin{array}{c} \begin{array}{ccc} C_1 & \cdots & C_n \end{array} \\ \begin{pmatrix} a_{11} & \cdots & a_{1n} \\ \cdots & \cdots & \cdots \\ a_{m1} & \cdots & a_{mn} \end{pmatrix} \end{array}$$

Source: Adapted from Pomerol and Barba-Romero (2012, p. 19)

In the particular case of the AHP, the decision matrices are different from Figure 2, as they gather the pairwise evaluation in relation to each variable of the immediately higher hierarchical level. For the problem about choosing an attack aircraft (Figure 1) with the AHP method, for example, seven evaluation matrices per expert would be necessary: one 6x6 (six rows and six columns) matrix for the pairwise evaluation between criteria, and six 3x3 matrices (three rows and three columns) for aircraft evaluations in relation to each criterion, as shown in Figure 3.

Figure 3 – AHP matrices

Objective

$$\begin{array}{c} \\ C_1 \\ C_2 \\ C_3 \\ C_4 \\ C_5 \\ C_6 \end{array} \begin{array}{c} \begin{array}{cccccc} C_1 & C_2 & C_3 & C_4 & C_5 & C_6 \end{array} \\ \begin{pmatrix} 1 & c_{12} & c_{13} & c_{14} & c_{15} & c_{16} \\ c_{21} & 1 & c_{23} & c_{24} & c_{25} & c_{26} \\ c_{31} & c_{32} & 1 & c_{34} & c_{35} & c_{36} \\ c_{41} & c_{42} & c_{43} & 1 & c_{45} & c_{46} \\ c_{51} & c_{52} & c_{53} & c_{54} & 1 & c_{56} \\ c_{61} & c_{62} & c_{63} & c_{64} & c_{65} & 1 \end{pmatrix} \end{array}$$

Criterion 1

$$\begin{array}{c} \\ A_1 \\ A_2 \\ A_3 \end{array} \begin{array}{c} \begin{array}{ccc} A_1 & A_2 & A_3 \end{array} \\ \begin{pmatrix} 1 & a_{12} & a_{13} \\ a_{21} & 1 & a_{23} \\ a_{31} & a_{32} & 1 \end{pmatrix} \end{array}$$

Criterion 2

$$\begin{array}{c} \\ A_1 \\ A_2 \\ A_3 \end{array} \begin{array}{c} \begin{array}{ccc} A_1 & A_2 & A_3 \end{array} \\ \begin{pmatrix} 1 & a_{12} & a_{13} \\ a_{21} & 1 & a_{23} \\ a_{31} & a_{32} & 1 \end{pmatrix} \end{array}$$

Criterion 3

$$\begin{array}{c} \\ A_1 \\ A_2 \\ A_3 \end{array} \begin{array}{c} \begin{array}{ccc} A_1 & A_2 & A_3 \end{array} \\ \begin{pmatrix} 1 & a_{12} & a_{13} \\ a_{21} & 1 & a_{23} \\ a_{31} & a_{32} & 1 \end{pmatrix} \end{array}$$

Criterion 4

$$\begin{array}{c} \\ A_1 \\ A_2 \\ A_3 \end{array} \begin{array}{c} \begin{array}{ccc} A_1 & A_2 & A_3 \end{array} \\ \begin{pmatrix} 1 & a_{12} & a_{13} \\ a_{21} & 1 & a_{23} \\ a_{31} & a_{32} & 1 \end{pmatrix} \end{array}$$

Criterion 5

$$\begin{array}{c} \\ A_1 \\ A_2 \\ A_3 \end{array} \begin{array}{c} \begin{array}{ccc} A_1 & A_2 & A_3 \end{array} \\ \begin{pmatrix} 1 & a_{12} & a_{13} \\ a_{21} & 1 & a_{23} \\ a_{31} & a_{32} & 1 \end{pmatrix} \end{array}$$

Criterion 6

$$\begin{array}{c} \\ A_1 \\ A_2 \\ A_3 \end{array} \begin{array}{c} \begin{array}{ccc} A_1 & A_2 & A_3 \end{array} \\ \begin{pmatrix} 1 & a_{12} & a_{13} \\ a_{21} & 1 & a_{23} \\ a_{31} & a_{32} & 1 \end{pmatrix} \end{array}$$

Source: Elaborated by authors, 2023

For this evaluation, a nine-point scale proposed by Saaty (1977), described in Chart 1, is used.

Chart 1 – Saaty's evaluation scale

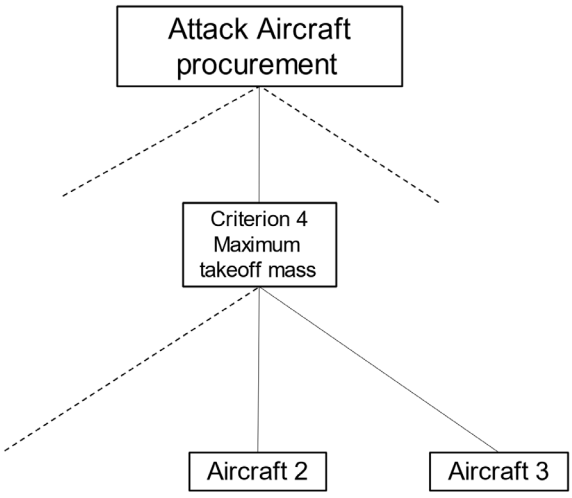
Intensity of pairwise ratio	Scale score	Description of pairwise evaluations
Equivalent	1	Two criteria are equivalent with respect to the objective Two alternatives are equivalent with respect to a criterion
Moderate	3	One criterion is slightly more important than another with respect to the objective One alternative is slightly more important than another with respect to a criterion
Strong	5	One criterion is more important than another with respect to the objective One alternative is more important than another with respect to a criterion
Very strong	7	One criterion is much more important than another with respect to the objective One alternative is much more important than another with respect to a criterion
Extreme	9	One criterion is extremely more important than another with respect to the objective One alternative is extremely more important than another with respect to a criterion
Intermediate	2, 4, 6, 8	Ratio scores by the nine-point scale intermediate values

Source: Adapted from Saaty (1977, p. 246)

The internal elements of the AHP matrices (Figure 3) indicate the values corresponding to the intensity of the ratio between two criteria or two alternatives. As in the comparison between aircraft 2 and aircraft 3, regarding criterion 4 (Figure 4), it is possible to assume that the expert considers the first alternative more important than the second. Therefore, element a_{23} of the evaluation matrix, in relation to criterion 4, would receive value 7, as this value is equivalent to the *much more important* expression in Saaty's scale. By reciprocity, element a_{32} would receive value 1/7 in the same matrix. In this way, the other matrices are assembled according to the expert's evaluations. The main diagonal of matrices is always composed of values 1, as each variable is equivalent to itself; thus, aircraft 3, for example, is equivalent to aircraft 3 in relation to any criterion.

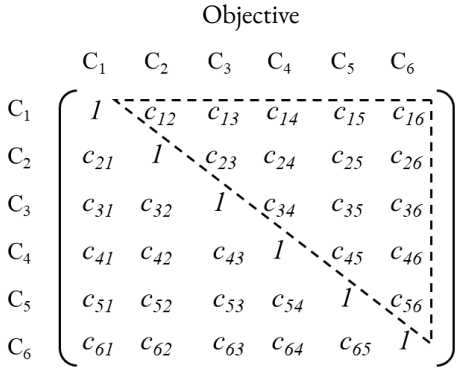
Generalizing the evaluations for n variables, the decision matrix should be composed of elements n^2, due to the structure of n rows and n columns. Regarding these elements, n of the main diagonal have to assume the value 1, as each variable is equivalent to itself. There would then be elements n^2-n to be filled in. However, half of this remainder is also obligatorily the inverse value of its reciprocal element (for example, the reciprocal element of a_{15} is the element a_{51}). In summary, it is only necessary to fill in the elements included in the dotted triangle in Figure 5 for each matrix.

Figure 4 – Extract of the hierarchical structure



Source: Elaborated by authors, 2023

Figure 5 – Evaluations required in an AHP matrix



Source: Elaborated by authors, 2023

3 AHP CALCULATION METHODOLOGY

AHP calculations originate from linear algebra, as it explores a database in matrix form and uses the concepts of eigenvector and eigenvalue of matrices. Equations (1) to (6), in the appendix of this article, are used for these calculations, as detailed in Liu and Lin (2016). The calculations in this research were performed on Excel software, but others are usually used, such as R and Python, including AHP-specific libraries (CHO, 2019; FANG; PARTOVI, 2021).

The logical consistency of the evaluations is also measured, with up to 10% of inconsistency being admitted by the evaluator (LANE; VERDINI, 1989). For example, an expert judges that A is more important than B and B is more important than C. By logic, it is not accepTable that A is equivalent to or less important than C. For three variables, this logical inconsistency is noticeable, but for a greater number of pairwise comparisons, it is common for the evaluator to make this type of mistake.

Depending on the hierarchical structure of the problem, an evaluator can devote considerable effort and time to carry out the evaluations, which can increase the probability of logical inconsistency of their judgments. This problem occurs in situations that demand flat hierarchical structures, that is, characterized by a significant number of variables at each level. To mitigate this AHP vulnerability, the scientific literature records some techniques to simplify data collection, reducing the effort/time spent by the expert and ensuring the process logical consistency. In the illustration of the problem about the attack aircraft procurement, with the 6-criteria structure (Figure 1), the simplified model proposed by Gavião, Lima and Garcia (2021) would require the evaluator to make only five judgments for this level, instead of the 15 foreseen in the original AHP model. This article does not delve into these procedures for simplifying AHP data collection, but it is possible to find different solutions in the literature (ÁGOSTON; CSATÓ, 2022; ALRASHEEDI, 2019; GAVIÃO; LIMA; GARCIA, 2021; LEAL, 2020; ZHOU et al., 2018).

4 APPLICATION AND RESULTS

To illustrate the AHP application to the problem in Figure 1, a database created by an expert was simulated, according to the pairwise evaluations in Figure 6, which are equivalent to the matrices in Equation (1) format. Thus, the expert should complete seven matrices of pairwise evaluations.

Figure 6 – Data collection by expert

	C_1	C_2	C_3	C_4	C_5	C_6
C_1	1	3	2	1/4	1/3	6
C_2	1/3	1	1/2	1/6	1/5	4
C_3	1/2	2	1	1/5	1/4	5
C_4	4	6	5	1	2	9
C_5	3	5	4	1/2	1	8
C_6	1/6	1/4	1/5	1/9	1/8	1

Criterion 1

	A_1	A_2	A_3
A_1	1	3	2
A_2	1/3	1	1/2
A_3	1/2	2	1

Criterion 2

	A_1	A_2	A_3
A_1	1	1/3	1
A_2	3	1	3
A_3	1	1/3	1

Criterion 3

	A_1	A_2	A_3
A_1	1	4	1/2
A_2	1/4	1	1/5
A_3	2	5	1

Criterion 4

	A_1	A_2	A_3
A_1	1	1/2	2
A_2	2	1	3
A_3	1/2	1/3	1

Criterion 5

	A_1	A_2	A_3
A_1	1	1/3	4
A_2	3	1	6
A_3	1/4	1/6	1

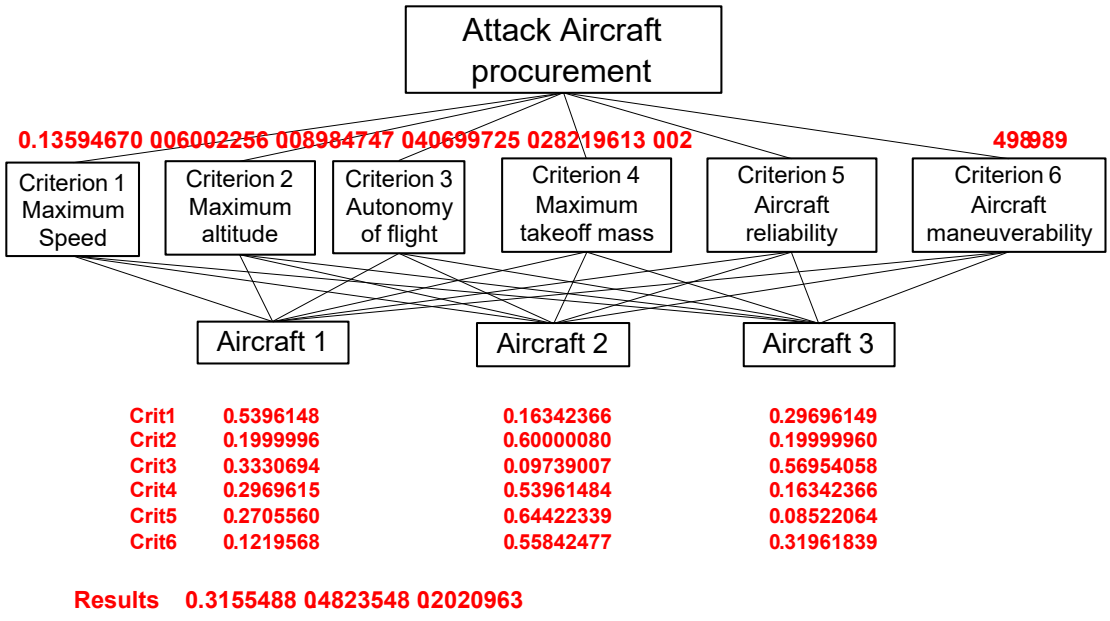
Criterion 6

	A_1	A_2	A_3
A_1	1	1/4	1/3
A_2	4	1	2
A_3	3	1/2	1

Source: Elaborated by authors, 2023

In the sequence of calculations, Equation (2) allows obtaining the weights of the variables of each matrix. Therefore, the matrix of pairwise evaluations of the six criteria produces their weights and each aircraft evaluation matrix produces the weights in relation to each criterion, as shown in Figure 7. By way of illustration, the criteria evaluation matrix indicated that the expert's preference as to criterion 4 had the highest weight among the others (40.69%), while criterion 6 was considered the least important for the choice of aircraft (2.49%). Below the aircraft level, Figure 7 shows their weights in relation to each criterion.

Figure 7 – Weights of each evaluation matrix



Source: Elaborated by authors

Then, Equations (3) to (6), in the appendix of this article, are applied to generate the CR of each matrix, allowing validation of the expert's preferences or indication of the need for a new round of evaluations. Table 1 presents the results of these calculation steps, and it is possible to identify that they are less than 10%, which validates the consistency of the expert's evaluations.

Table 1 – CR calculation sequence

Matrix	Criteria	Aircraft Criterion 1	Aircraft Criterion 2	Aircraft Criterion 3	Aircraft Criterion 4	Aircraft Criterion 5	Aircraft Criterion 6
λ max	6.2544	3.0092	3	3.0246	3.0092	3.0536	3.0183
CI	0.0509	0.0046	$5.56.\ 10^{-12}$	0.0123	0.0046	0.0268	0.0091
RI	1.24	0.58	0.58	0.58	0.58	0.58	0.58
CR	0.0412	0.0079	$9.58.\ 10^{-12}$	0.0212	0.0079	0.0462	0.0158

Source: Elaborated by authors, 2023

The results of final preferences as to each aircraft correspond to a weighted sum of the weights obtained at the different levels. For aircraft 1, for example, the result is equivalent to the sum of the portions (0.5396148 x 0.13594670) referring to weighting of criterion 1 (0.1999996 x 0.06002256), to criterion 2, (0.3330694 x 0, 08984747), to criterion 3, and so on, until criterion 6. For this reason, Table 2 presents the final preference as to the aircraft, which reflects the consulted expert's judgments. For him, aircraft 2 should be chosen, as it obtained the highest result, 48.23%.

Table 2 – Final weights

Alternatives	Final weight	Order of preference
Aircraft 1	0.3155488	2
Aircraft 2	0.4823548	1
Aircraft 3	0.2020963	3

Source: Elaborated by authors, 2023

5 CONCLUSION

This article aimed to address decision support in defense procurement problems, showing how to structure it through the multi-criteria method, specifically presenting the AHP method. The problem about defense procurement fits the multi-criteria decision theory, as the attributes of products, systems and their components can be selected according to decision criteria and, in general, the set of possible solutions to the problem is finite (ARDIL, 2021). The high technology and the major resources required for the production of these systems make the defense market restricted to a few manufacturers. These characteristics allow adjusting the problem to the multi-criteria decision support methods available in operational research.

The AHP has been frequently used in defense procurement problems, mainly due to its simplicity, logic, and the possibility of validating the experts' evaluations (GAVIÃO; DUTRA; KOSTIN, 2021). The use of a scale of perceptions to make a variable pairwise comparison facilitates the evaluators' judgment, as it avoids the need to use performance measures that are often non-existent or unfeasible to experts. In addition, the evaluators' logical consistency can be easily verified with the help of calculations from linear algebra, indicating whether the judgments are within an acceptable range or whether they need to be redone or even discarded. The AHP calculation equations can be implemented in different pieces of software, including Excel, R, and Python, among others (FRANEK; KRESTA, 2014; LIU; LIN, 2016).

This article brought a simulated application in order to show how data collection and AHP calculations should occur. The problem showed the evaluations of a single expert, but it is important – and desirable – that other stakeholders participate in the process. Thus, it is possible to obtain different points of view, resulting from personal or interesting sectoral experiences. Results from different experts can, for example, be aggregated by arithmetic means, indicating a general idea of preferences. In the model explored here, three aircraft were evaluated under six criteria, indicating the order of choice of the simulated expert.

APENDIX

$$A = \begin{bmatrix} 1 & a_{12} & \dots & a_{1n} \\ 1/a_{12} & 1 & \dots & a_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ 1/a_{1n} & 1/a_{2n} & \dots & 1 \end{bmatrix}$$

A: matrix of pairwise evaluations of one expert
aij: pairwise evaluation value corresponding to the Saaty's scale
n: number of criteria/alternatives (1)

$$w_i = \frac{\left(\prod_{j=1}^{n} a_{ij}\right)^{1/n}}{\sum_{i=1}^{n}\left(\prod_{j=1}^{n} a_{ij}\right)^{1/n}}$$

wi: matrix eigenvector (weights of the criteria matrix or of alternatives)
i: matrix row indicator
j: *i*: matrix column indicator
Σ: sum
Π: product (2)

$$A^s = \begin{bmatrix} 1 & a_{12} & \dots & a_{1n} \\ 1/a_{12} & 1 & \dots & a_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ 1/a_{1n} & 1/a_{2n} & \dots & 1 \end{bmatrix} \times \begin{bmatrix} w_1 \\ w_2 \\ \vdots \\ w_n \end{bmatrix} = \begin{bmatrix} w_1' \\ w_2' \\ \vdots \\ w_n' \end{bmatrix}$$

As: product matrix of evaluations and eigenvector (*w*) (3)

$$\lambda_{\max} = (1/n) \times (w_1'/w_1 + w_2'/w_2 \cdots + w_n'/w_n)$$

λmax: maximum eigenvalue of the reciprocal matrix (4)

$$IC = \frac{\lambda_{\max} - n}{n-1}$$

CI: Consistency Index (Table 1) (5)

$$RC = \frac{IC}{IR}$$

RC: Consistency Ratio (evaluator logic)
RI: Random Index, calculated based on Table 1 6.

Table A1 – AHP Random Index Values

Number of matrix variables	1	2	3	4	5	6	7	8	9
Random Index (RI)	0	0	0.58	0.9	1.12	1.24	1.32	1.41	1.45

Source: Adapted from Liu and Lin (2016)

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Proposals for requirements definition in defense systems projects: an application in new cruise missile developments

Propuestas para la elaboración de requisitos en proyectos de sistemas de defensa: una aplicación en nuevos desarrollos de misiles de crucero

Abstract: The paper presents proposals for definition of project requirements in defense systems, considering upcoming developments of cruise missiles as an application. Based on the Tomahawk missile history, the text recommends interactions between the project's sponsoring organization and development engineers with a process of adjustments and tailoring among the user's initial expectations, the technology readiness level (TRL), and national industrial skills. This task aims to provide in-depth analyzes and solutions to technically advise authorities in the decision-making process involving engineering projects related to the national defense strategy. In addition, the authors created a new type of requirement, the "zero requirements" It is characterized by an immutable demand from the main stakeholder, which decisively affects the product's final characteristics. Finally, the article proposes improvements in the requirements writing by adding new information fields to understand the user's initial goals better and provide an initial resource/cost/time-consuming estimation.

Keywords: project requirements, cruise missile, technical advice for decision-making, system engineering, Tomahawk.

Resumen: Este artículo presenta propuestas para la elaboración de requisitos relacionados con proyectos de sistemas de defensa, teniendo como aplicación práctica en los próximos desarrollos de misiles de crucero. Con base en la historia del misil Tomahawk, se recomienda la interacción entre la organización patrocinadora del proyecto y los ingenieros de desarrollo en un proceso de ajustes y adaptaciones entre la expectativa inicial del usuario, el nivel de desarrollo tecnológico y las capacidades industriales nacionales. Esta tarea puede brindar análisis en profundidad y soluciones para asesorar técnicamente a las autoridades en la toma de decisiones que involucren proyectos de ingeniería relacionados con la defensa nacional. Aún se crea una nueva clase de requisitos, los requisitos cero, que se caracterizan por contener una demanda inalterable por parte de la autoridad decisoria, afectando decisivamente las características finales del producto. Finalmente, se sugieren complementaciones al texto de los requisitos para comprender mejor los deseos del usuario y permitir prever los plazos y los recursos materiales, financieros y humanos demandados.

Palabras clave: requisitos de diseño; misil de crucero; asesoramiento técnico para la toma de decisiones; ingeniería de Sistemas; Tomahawk.

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1 INTRODUCTION

Project requirements are attributes in a system. They consist of simple sentences that identify the capacity, characteristic, or quality level of a system and are designed to add value or present utility to the user (or client) (YOUNG, 2003).

They also provide the main foundations that enable a development team to define all the other associated technical work in the course of a project, that is, the development of the concept, study of feasibility, development of the solution, manufacture of prototypes, performance of engineering tests and tests necessary to prove each of these project requirements (INTERNATIONAL COUNCIL ON SYSTEMS ENGINEERING, 2015; UNITED STATES, 2020a).

In the development of defense systems, each user's need registered as a project requirement (whether technical or operational requirement) demands a certain level of technological maturity (Technology Readiness Level – TRL) (UNITED STATES, 2020b) necessary for the implementation of the final solution. The process of developing the set of requirements must therefore consider the technologies mastered by the national industrial base and the total resources made available (financial, human, material, etc.) (UNITED STATES, 2001). Thus, weighing and selecting characteristics/functionalities among options that prioritize the rapid acquisition of a military employment material (MEM) or the acquisition of knowledge and capabilities still absent in the country's industrial park (LIMA, 2007), which usually requires more time, is possible.

Note that these factors are interrelated and, in practice, require that the project requirements be elaborated in an interactive way in a process of adaptation and adjustment between the initial expectation of the user and the technological scenario of the country (NATIONAL AERONAUTICS AND SPACE ADMINISTRATION, 2017), having as decision variables the time available to obtain the defense system and the available resources (or the size of the effort that is intended to be expended) (UNITED STATES, 2001).

This fact requires, preferably before the decision to start the development, a joint work between the user (or the sponsoring organization) and the engineers/managers of the project (UNITED STATES, 2020a). An engineering technical team, experienced in the subject of interest, can identify limiting factors and obstacles in each potential requirement (initial need/desire) (RICH; JANOS, 1994). The objective is to supply the sponsor with information that allows him to visualize the general scenario, advising him in making decisions that involve the definition of the best way to obtain what was intended, either with adaptations in the requirements initially proposed (path with priority for shorter obtainment time and/or lower cost), or by preparing auxiliary projects whose results are fundamental in the main project (path with priority for the object to be developed, regardless of the time frame, the technological capacity available, and the resources required).

The importance of this joint work is evident in the development of smart munitions, especially tactical cruise missiles, since integrating different systems and subsystems in a manufacturing environment that is specific and dedicated to this purpose is required (FLEEMAN, 2012). Many of these complex components may be available only in foreign countries,

and problems such as trade embargoes may prevent or delay a national enterprise (GALDINO; SCHONS, 2022). Such issues may justify a strategic approach, with the opening of an auxiliary project for the national obtainment of an item not yet technically mastered or not manufactured by the country's industry (UNITED STATES, 2002, 2022b).

In Brazil, so far and based on the experience of acting in smart munitions projects in the Brazilian Army, developments with an initial interactive process between the sponsoring body of the enterprise in the Brazilian Army and the engineering team of the project with the ultimate goal of elaborating the total set of requirements are not foreseen (LIMA, 2007; BRAZIL, 2022), and thus not customary.

The lack of interaction in the initial phases of innovation processes is one of the challenges to be overcome within an effort to implement a culture with a synchronous, systemic, and integrated vision of the cycles of technological innovation and life of a Defense Product (PRODE) (BARBOSA; BUENO CALDEIRA, 2021). The expansion of the interrelations between the agents of innovation is beneficial to the Defense Industrial Base, which would consequently bring the growth of the country's deterrent power (FRANCO AZEVEDO, 2018).

The absence of interinstitutional partnerships is a gap that still constitutes an obstacle to military innovation (BARBOSA; BUENO CALDEIRA, 2021). This article aims, therefore, to contribute with an increase in the interaction between the sponsoring agencies and the developers in innovation cycles of factors that generate military capabilities. The aim is to propose a specific class of requirement, whose data are established jointly and in common agreement between the operational user and the engineer's corps, still in the early phase of the military innovation cycle. And since this class of requirement is unnamed in the literature, this article proposes and adopts the term zero requirement.

The intention is that the zero requirement to represent only PRODE operational requirements that cannot be changed or eliminated, even in the face of challenges of a technical, commercial (embargoes, for example), or manufacturing nature, and that must prevail over all others. These definitions will allow a better understanding of the material to be developed and a more accurate provision on the costs involved, the efforts required, and the deadlines demanded.

The final wording of each zero requirement will be reached with the help of increased interactions between those responsible for establishing the primary operational desires and those whose task is to convert these mandatory needs into engineering language, with the consequent identification of viable technological solutions and establishment of the physical or performance characteristics necessary for the defense product.

Once this initial interaction is completed, obtaining, in subsequent moments, the production of the document with the total set of project requirements (operational, technical, logistic, and industrial), as already established in the General Instruction of the Army (BRASIL, 2022), is possible.

To deepen the topic, section 4 of this article addresses the elaboration of zero requirements for smart munitions, in particular, cruise missiles, and identifies the relevant categories. Section 5, in turn, presents the importance of ordering these categories according to attainment priority. Section 6 illustrates which fields of information must be filled in for each zero requirement. Section 7 has the final considerations.

2 BIBLIOGRAPHIC REFERENCE

2.1 History of cruise missile development – the Tomahawk missile

The proposal to establish a new class of requirements, the zero requirements, has its importance illustrated in the history of the development of the American Tomahawk cruise missile.

In 1972, SALT I (Strategic Arms Limitation Talks), a set of bilateral conferences and international treaties between the United States and the Soviet Union, established restrictions aimed at curbing the advance of the use of ballistic missiles with nuclear payloads. In addition to the context of nuclear war, the United States were concerned regarding the advancement of Soviet technologies related to anti-ship missiles and the use, in Vietnam, of remotely piloted aerial vehicles capable of gathering intelligence on hitherto inaccessible or highly defended areas (ROCKET AND MISSILE SYSTEM, 2015).

Including another type of weaponry capable of dealing with new enemy threats and of circumventing the growing obstacles imposed by restrictions of international agreements was clearly needed. The U.S. efforts in this direction occurred in 1970, when the concept of a strategic cruise missile (high range), with submerged launch, was demonstrated as feasible after a study conducted by the Center for Naval Analysis (CNA) (WERRELL, 1998). The United States had an extensive fleet of nuclear ballistic missile submarines (SSBN) in addition to attack submarines (SSN), both vital weapons in the struggle for dominance of the sea during the Cold War (1946–1991) (POLMAR; MOORE, 2004).

Despite a proposal to develop a long-range version of the Harpoon anti-ship missile, due to a greater ease and speed in obtaining it, an alternative program was proposed in 1971, the Submarine Tactical Anti-ship Weapon System (STAWS), aiming to design a missile with a range of 500 miles (800 kilometers (Km)). In 1972, a new name was assigned to the development by Secretary of Defense Melvin Laird, STAWS was renamed the Submarine-Launched Cruise Missiles (SLCM) (YENNE, 2018).

At the beginning of the SLCM program, only submarines were considered as means of launch. Multiple options were debated to define how cruise missiles would be stockpiled and primarily launched horizontally (via torpedo tubes) and/or vertically (in the same way as a ballistic missile). There were also debates about building a new class of submarines or adapting the fleet's attack and ballistic missile submarines. The decision came from Admiral Hyman Rickover, considered the father of the nuclear-powered Navy. The new cruise missiles would be launched from the torpedo tubes of existing submarines. This decision alone immediately limited the diameter of the new missile to 21 inches (533 millimeters (mm)) and the overall length to about 20 feet (6,096 mm) (YENNE, 2018).

After reviewing different developer proposals, the U.S. Navy selected two companies as finalists, each with different technical solutions. Convair, a division of General Dynamics, built a prototype (Figure 1) under the designation YBGM-109. Ling-Temco-Vought produced a demonstrator called the YBGM-110. The winner was Convair, and its YBGM-109 was successful during

two launches aimed at evaluating the submerged launch with the subsequent transition to cruise flight. The YBGM-110, however, failed during the wing-opening process (YENNE, 2018).

Figure 1 – During the testing phases, the Convair prototype was known only as the General Dynamics Cruise Missile.

Source: Yenne, 2018.

However, the objective of this article is not to tell the origins of the Tomahawk cruise missile, but rather to extract important decisions made at the time and convert them into activities that advocate the interaction between operational agents and technical agents, still in the initial phase of the military innovation process, to improve the national development projects of new defense technologies.

2.2 Aspects of the administrative model of the life cycle of military employment materials in the Brazilian Army

Currently, the Brazilian Army manages the development of military employment systems and materials based on a General Instruction (EB10-IG-01.018) (BRASIL, 2022), whose purpose is to order and describe the processes, activities, and events that occur during the life cycle of the material (not only those to be developed, but also those already developed at the initiative of third parties), fixing the order and the responsible bodies.

According to this General Instruction, after identifying a demand to fill a gap or maintain operational capacity, the Operational Direction Body begins, with the doctrinal production cycle of the Land Military Doctrine System, to elaborate a document called Doctrinal and Operational Conditioners of a Military System of Defense of the Land Force (CONDOP SMD F Ter), which should describe the doctrinal and operational aspects, such as: mission, the operating environment, the types of operation, the functionalities to be performed, the expected

performances, the necessary logistical support, and the technological, material or human constraints that may limit the operation.

This action foreseen in EB10-IG-01.018 is adherent to what is desired from the point of view of development engineering, that is, the first step when starting a project of a new defense system should be to know and understand the initial desires of the sponsoring organization of the enterprise (UNITED STATES, 2020a).

The steps aimed at analyzing project requirements impose significant challenges both for the agency that will stipulate its operational needs and for those responsible for the system engineering of the project, and deficiencies in this process cause delays in the enterprise and greatly increase its cost (PIASZCZYK, 2011). In addition, inadequate wording of requirements, whether from ambiguities or the erroneous definition of functionalities or characteristics, affects all subsequent engineering and project planning activities (CLARK; HOWELL; WILSON, 2007).

Thus, preparing the CONDOP SMD F Ter with the participation of the engineers who will act in the new development, supplying them with specific information that allows them to already draw the first estimates of costs, deadlines, and necessary material and human resources, is recommended, in addition to enabling the beginning of the writing of the technical, logistic, and industrial requirements.

With reference to the Tomahawk's track record, one clearly observes the initial motivation of the United States to fill a gap in its operational capability: international agreements that limited the use of its nuclear arsenal and the emergence of new enemy weapons systems. The decision of the US high command was to develop an ammunition that, despite having existed since 1918 in rudimentary versions (YENNE, 2018), would need to have a range with dimensions that would enable its use at the strategic level (WERRELL, 1998).

In this case, two important points for consumption of development engineering are identified. The first is prior knowledge of gaps in operational capability (or the facts that prevent its maintenance). The concept of operational capability is related to the attitudes that units must have oriented to obtaining a strategic, operational, or tactical effect, usually by combining personnel, instruction, training, equipment, logistics, and organizational structure, based on an employment doctrine (BRASIL, 2015).

The other point is to be aware of the options preliminarily identified as solutions (military employment systems or materials). Both enable a group of experienced engineers to contribute new technical propositions or feasibility analyses (RICH; JANOS, 1994) and, in a joint debate with the sponsoring organization, establish the most appropriate type of material, having already considered possible technical limitations, the level of national technological maturity, and the capacities installed in the industrial park (GIRARDI; FRANÇA JÚNIOR; FERREIRA GALDINO, 2022; UNITED STATES, 2002).

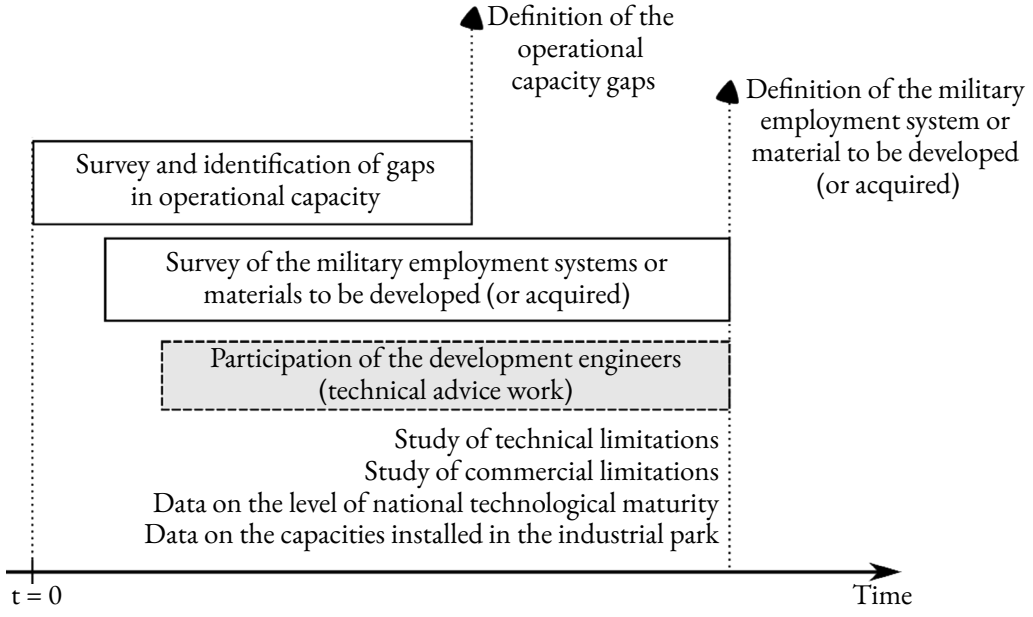
It is an interactive work with the purpose of advising the decision making regarding the type of material or system to be developed, promoting initial estimates of the technological needs and the costs/deadlines involved.

Similar dynamics were observed when the Center for Naval Analysis (CNA), about two years before Admiral Hyman Rickover's decision to use submarine-launched

cruise missiles, conducted engineering studies to verify the feasibility of launching this type of ammunition when submerged. The CNA is a research organization comprised of a cadre of experts with training and experience in the field of defense that serves the public interest by providing in-depth analysis and solutions to assist U.S. government leaders in choosing the best path in defining policy and managing U.S. defense-related operations and projects (CNA, 2022).

Therefore, we infer that in projects for the development of complex defense systems, a temporal division is recommended in the work of surveying and identifying gaps in operational capacity and of surveying options of military employment systems or materials to be developed or acquired (Figure 2). Thus, to contribute to the increase of interaction between the agents of innovation still in the initial phase of the enterprise, the participation of an experienced and cohesive team of engineers alongside the sponsoring organization is suggested to assist in the work of selecting the military employment system or material to be developed.

Figure 2 – Illustration of a way to increase the interaction between the agents of military innovation, by including of the participation of a team of development engineers still in the phase of survey and identification of gaps in operational capacity and survey of options of systems or materials of military employment to be developed (or acquired).



Source: Figure elaborated by the authors, 2022.

A complementary use of the dynamics illustrated by Figure 2 is carrying out the documentary record of the gaps found in the operational capacity, since those are important raw materials for elaborating the technical, logistical, and industrial requirements in subsequent stages. In smart ammunitions projects, some examples of these gaps are: (i) the means of launch (in the case that resulted in the project of the Tomahawk, there was until then no possibility of launching cruise missiles when submerged); (ii) certain targets that need to be

neutralized (warships or strategic targets such as bridges, airfields, refineries); and (iii) a certain region of the national territory with the possibility of improvement in the defensive system (distances between potential targets and launch points, and the peculiarities of the operational environment). Note that a gap may also turn out to be the absence of national mastery of a specific technology, such as a certain type of warhead or internal component of the ammunition, such as electromechanical actuators, inertial systems, or cruise motors.

An example of documentation (registration) that condenses operational gaps filled with the help of the use of cruise missiles is the study on an anti-access and area denial strategy at the mouth of the Amazon River (CALDAS, 2020). Just by way of brief illustration, the reading of the research, under the focus of engineering, makes it possible to extract climatic conditions and define the respective applicable technical standards, establish criteria and logistical solutions for displacement and storage of the system/ammunition, and understand the nature of the targets, with all the consequent determination of necessary characteristics of ammunition performance.

3 THE CREATION OF ZERO REQUIREMENTS AND THEIR CONTRIBUTION TO INCREASED INTERACTION BETWEEN MILITARY INNOVATION AGENTS

From the point of view of an engineer in the technical leadership/management of a new project, the beginning of the development of a smart ammunition requires the knowledge of specific data provided only by the client (or sponsoring organization). These are operational constraints that, under no circumstances, can be removed or changed, even in the face of technical, manufacturing, or commercial challenges (embargoes, for example).

Although in a first reading these impositions provided by the operational agent (client) can be interpreted only as the already existing operational requirements (BRASIL, 2022), the experience in projects of development of complex defense systems (REZENDE *et al*., 2021; REZENDE *et al*., 2022), such as cruise missiles and guided rockets (FLEEMAN, 2012), shows the indispensability of understanding, recording and classifying specific constraints that represent operational requirements, imposing restrictions on the developer and determining the aspect, cost, and time frame to obtain the product (BOORD; HOFFMAN, 2016; KRILL, 2001).

The process that culminated in the development of the Tomahawk missile evidences one of these immutable constraints under any conditions. Despite any other operational requirement, the new missile should have the dimensions of the torpedo tubes of the submarines of the United States Navy (YENNE, 2018). And this characteristic could not be changed, even in the face of any technical difficulty.

This example illustrates the repercussions from the engineering perspective. Some project variables, for example, the range, the volume available for fuel, and the payload capacity, would suffer direct impact (FLEEMAN, 2001) and would have their values defined or limited only based on a single operational imposition. Not to mention the very possibility of failure of the enterprise, which would be noticed only at an advanced stage of development, if this imposed operational condition required effort (material, financial, technological, etc.)

above what was possible and was included only in the set of all other operational requirements, as executed, so far, in the developments of the Brazilian Army (BRAZIL, 2022).

Immutable operational impositions are common in the project of new systems or materials for military employment. Such as one of the Basic Operational Requirements of the Tactical Cruise Missile System for the Brazilian Army (BRASIL, 2012), which establishes that ammunition must be launched from the Multiple Launch Vehicle (AV-LMU) that integrates the ASTROS system (ASTROS, 2021; OLIVEIRA ALVES, 2022), from the company Avibras. This single requirement immediately restricts the maximum length of the ammunition (the limit is equal to the length of the AV-LMU launch platform) and, consequently, may make it impossible, during the execution of the development project, to achieve several other operational requirements related to performance or functionality, such as the range and warhead capability (FLEEMAN, 2001). In extreme cases, the outcome will be the impracticability or reduction of previously desired operational capabilities, a fact that often occurs in the innovation of defense systems (UNITED STATES, 2008).

Having as a good practice sample in obtaining defense products the initial development process of the Tomahawk missile, in which the interaction between agents of innovation provided the execution of early feasibility and engineering studies on immutable operational impositions, and allied to the impacts that specific requirements of defense systems can have on obtaining the defense product (PRODE), a new class of requirements is established, called zero requirements.

Thus, the challenge lies in the prior identification of the constraints that will be the basis for the entire construction of the engineering project (zero requirements). An interactive work between the operational decision-makers and the team of development engineers is recommended to evaluate the customer's requests with high potential impact on the engineering solution (evaluation of the effects of interrelationship between requirements arising from the operational aspect). This action also brings as a benefit the increase in interactions between operational and technical agents in the early stages of the military innovation process.

Up to this point, we infer that different defense systems have their specific operational constraints that are more likely to be imposed and have a high risk of affecting all other engineering decisions and solutions throughout PRODE development.

To deepen the proposal for the creation of zero requirements, its concept is expanded in the following sections considering the case of a defense system characterized by cruise missiles, with the survey of its main categories to be debated in the process of interaction between the agents of innovation. The importance of the correct relative ordering between the zero requirements and the set of information to be incorporated into their text will also be addressed in this article.

4 ZERO REQUIREMENTS FOR CRUISE MISSILES

In the case of cruise missile developments, we propose to separate the zero requirements into the following categories: means of launch, range, target types (and destruction/neutralization effects), accuracy, performance constraints, countermeasures, logistical aspects, and critical technologies.

4.1 Means of launch

The means of launch category should contain all the forms envisaged for the launch of the new missile, be they land, sea, and air. The way a missile is launched is one of the main variables of change in the appearance and geometry of the ammunition (FLEEMAN, 2001), and, therefore, is a typical zero requirement. The cases of munitions with multiplatform launch forecast require several adaptations in their fuselage and in the launcher receptacles (containers or canisters). For the launch from the air, for example, it should be provided for the insertion of support handles for fixing the missile to the pylons of the launching aircraft and localized structural reinforcements, all of which increase the weight and change the internal volume of the missile. The unintended consequences are a shorter range and/or reduced payload capacity, based on the same geometry.

Figure 3 – Launch of the RGM-84 Harpoon (anti-ship missile), from a canister aboard the battleship USS Leahy.

Source: Yenne, 2018.

4.2 Range

The range category is one of the main operational requirements that characterizes a smart ammunition. Despite being commonly interpreted as the distance from the launch point to the target, the range has, for aerial vehicles such as cruise missiles, a strong dependence on the flight profile (flight trajectories, speeds, and altitudes). Therefore, the numerical value of the range should always be treated in conjunction with the operating envelope.

4.3 Target types (and destruction/neutralization effects)

Also highly relevant, the types of targets to be hit (and the expected effects of destruction/neutralization) directly influence various project decisions at both the technical/managerial and strategic levels. The choice for a particular target type impacts, among other factors, the selection of the terminal navigation sensor (seeker) and the warhead (high explosive, multiple, thermobaric, etc.).

Despite Brazil already having some initiatives to develop technologies related to seekers devices (TECNOLOGIA..., 2015) and finished products (active auto director radar) by a Brazilian company with the support of a foreign nation (OMNISYS, 2022), the need to shoot down certain types of target, alongside other operational constraints, may lead to the obligation to develop a new device, whose technology is not yet fully in the national domain.

In this context, project leaders and managers must act to create tasks that result in obtaining an adequate component, which can mean opening a project in parallel, with their own team and resources. This same strategic decision was made by the American company Raytheon (RAYTHEON, 2015), in preparation for the modernization process of the Tomahawk Block IV. Raytheon began an independent development of a new multi-mode seeker (Figure 4) to enhance the capabilities of the U.S. arsenal's main cruise missile.

Figure 4 – Captive flight test (2015) of the multimode seeker developed by the American company Raytheon. The seeker prototype was installed on a Tomahawk nose fixed to the front of a T-39 aircraft.

Source: Raytheon, 2015.

4.4 Accuracy

The term accuracy represents the degree of proximity of an estimate to the actual parameter. In terms of artillery weapon systems, accuracy means the probability of the ammunition's point of impact (estimate) reaching the actual target desired (real parameter). The term precision, on the other hand, means the degree of proximity of the observations to their mean. In the case of ammunition, we have the grouping of impacts in relation to their average, regardless of whether this grouping is close to the actual target (GUERRA; SANTOS, 2020).

Figure 5 – The circle on the left represents a high accuracy and a high precision. The circle on the right indicates low accuracy and high precision.

Source: Guerra; Santos, 2020.

Figure 6 – The circle on the left represents a high accuracy and a low precision. The circle on the right indicates low accuracy and low precision.

Source: Guerra; Santos, 2020.

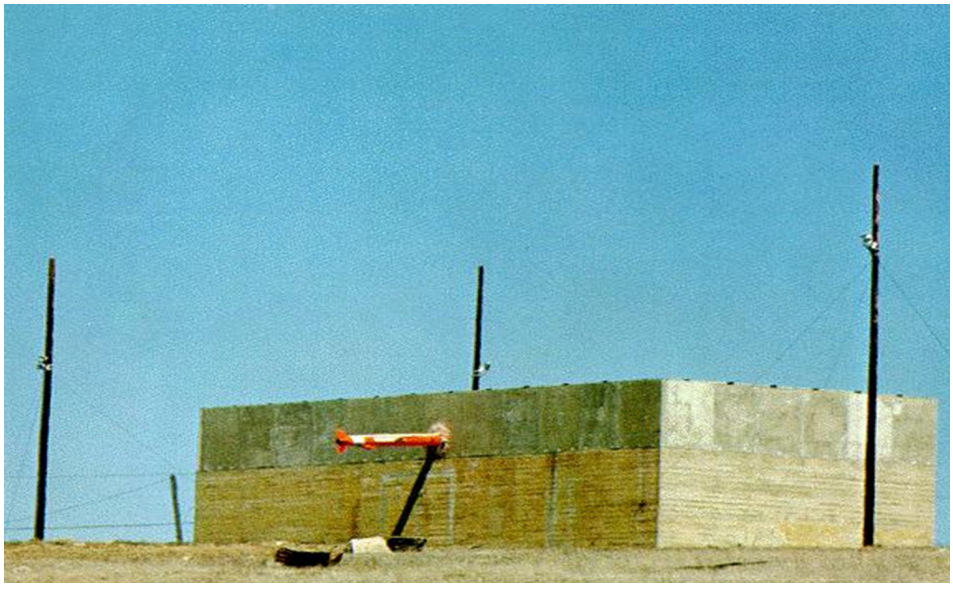
Another expression widely used by military operators and engineers dealing with weapon systems with ammunition use is the circular error probable (CEP). The basic concept of CEP lies in the fact that it is an estimator that informs the region in which they are expected to obtain 50% of the impacts after the employment of a weapon system.

The choice of a CEP value (or any other data on the accuracy of the ammunition) has a strong impact on the selection of internal components responsible for the correct positioning of the missile in its previously programmed trajectory, such as the inertial system and the terminal navigation system (seeker). The greater the need to ensure a drop point close to the target, the greater the requirement for highly accurate navigation sensors, which ultimately means adopting technologies with maturity levels considered low in Brazil.

On the other hand, adopting components manufactured by other countries has the possibility of leading to future trade embargoes and, at crucial moments of development, such as the final phase of product homologation tests for producing a pilot batch.

The option to achieve a certain value of accuracy may be linked to a strategic decision to start a separate development of technologies associated with navigation systems, with the mandatory approval and industrialization of the item.

Figure 7 – Flight test of the Tomahawk cruise missile launched from a submarine off the coast of California to a target in a United States Navy area located on the Island of São Clemente, California (NICKLAS, 2012).



Source: Nicklas, 2012.

4.5 Performance constraints

Performance constraints should be interpreted as imposing critical parameters for fulfilling the mission, in the various types of operation. Typical examples for cruise missiles are the minimum flight height and speed during cruise flight.

A missile intended to neutralize only warships already has its minimum flight height determined by the engineering solution, and the sponsoring organization has no need to establish a minimum value in its operational requirements (the necessary operational information is the target type, that is, the neutralization of warships of a certain class, for example). In this case, the flight height will be stipulated in technical requirements (the minimum flight height will depend on the state of the sea, to allow the flight profile close to the sea, or sea skimming).

For missiles intended to attack ground positions, minimum flight heights are related to the types of anti-aircraft battery or threat detection radars present during an operation, and values provided by the operational aspect will be used to adapt the engineering solution.

A similar situation occurs with cruising speed, making it more useful for the developer to understand the operational scenario than to obtain a numerical speed data.

Other examples of performance constraints are the requirement to operate in a GPS-denied space and the use of a certain constellation of satellites for communication between the ammunition and the ground station (route changes or applying mission abort commands). Note that such constraints also involve the use of technologies not yet fully established in Brazil, for example, high precision inertial systems and anti-jamming[1] GPS devices.

4.6 Countermeasures

Several countermeasures were developed to neutralize cruise missiles en route to the target. The RAND Corporation (SPEIER; NACOUZI; MCMAHON, 2014) summarizes the main countermeasures created to neutralize the threat posed by missiles, in their work on ways to deter the proliferation of this type of ammunition in the world.

The main performance variables related to protecting a cruise missile in flight are: flight altitude, trajectory (maneuverability), speed, and stealth level (JOHNSTON, 2000), which is associated with the radar cross section (RCS) and infrared signature.

Note that only one of these aspects, the cruising speed, directly stipulates the type of motorization to be installed or developed. Cruise missiles with supersonic speed around Mach 3 generally adopt ramjet engines (FRY, 2004), which, alongside scramjet engines (hypersonic speeds, above Mach 5), have not been finalized in Brazil. Therefore, an operational imposition for a cruising speed above the speed of sound will necessarily bring an increase in time and costs for obtaining a new engine.

Similarly, the levels of stealth directly influence the aspect of the final solution, either with application of radiation-absorbing material to the body of the missile, or by the design of the fuselage with facets aimed at reducing the radar signature.

4.7 Logistical aspects

Munitions with a high technological degree require a specific logistics, composed of a complex support system, even in times of peace (DANTAS, 2021).

Some logistical aspects have a high potential impact on the final solution of a new missile and should be addressed and incorporated into technical discussions in the early stages of development. Just as an illustration, the frequency required between maintenance activities (time interval in which the ammunition is removed from the magazine and moved to perform any overhaul or maintenance procedure) is mentioned; the use or

1 Anti-jamming GPS devices protect GPS signal receivers from intentional interference (jamming).

suppression of portable testing equipment (diagnosis of electronic and mechanical systems to verify that the missile is fit to be launched); the type of fuel used in the cruising engine; and the requirement that ammunition must remain inside the launcher container throughout the life cycle of the material.

Thus, considering logistical factors as zero requirements is also important.

4.8 Critical technologies

An operational gap may turn out to be the absence of national mastery in certain technology adopted in military employment systems or materials. For smart munitions, Brazil still needs to make advances in the homologation and industrialization of inertial navigation devices and terminal navigation systems (seekers – active, semi-active, and passive). Developments in engines to enable supersonic (ramjet engines) and hypersonic (scramjet engines) cruising speeds are also noteworthy, as well as advances in the production of such as thermobaric weapons.

Naturally, such work will require higher costs and, mainly, time, and it is up to the sponsoring organization to decide to develop critical technologies.

The development of cruise missiles suffers several restrictions, either from unilateral trade embargoes of nations that have critical components (engines, inertial devices, etc.), or by export control mechanisms of items listed as prohibited in international agreements, such as the MTCR (Missile Technology Control Regime) (MISSILE TECHNOLOGY CONTROL REGIME, 2022). Note that the emergence of the Tomahawk missile was due to a restriction imposed by one of these agreements (SALT I), which limited the use of the US nuclear arsenal.

Once the zero requirement categories have been elucidated, they can be summarized in a single table with hypothetical examples (Table 1). The numbering "0.?" shown in Table 1 indicates the proposed symbol for this requirement class. The "0" represents that this is a zero requirement and the marking "?" indicates that after selecting the operational impositions, they should be ordered in a priority criterion.

The examples in Table 1 aim to illustrate that a certain operational imposition in a certain category automatically exempts from filling out another (marked as unassigned). By establishing a constraint of sinking warships, accuracy and countermeasures become immediate consequences, and it is up to the developers to draft the associated technical requirements. Also, completing all categories is not obligatory, only those that represent an operational requirement that cannot be changed, despite any other operational requirement or technical, manufacturing, or commercial difficulty (in the case of Table 1, no constraints was assigned to the logistical aspect category). However, always informing if the sponsoring organization accepts the use of imported COTS components or if there is an interest in the use/development of only domestic items (critical technologies category) is recommended.

Table 1 – Zero requirement categories for cruise missiles and hypothetical examples.

Zero requirements for cruise missiles		
Numbering	**Category**	**Example**
0.?	Means of launch	Launch of the AV-LMU vehicle of the ASTROS system
0.?	Reach	200 Km
0.?	Target types (and destruction/ neutralization effects)	Sinking corvettes (similar to the Inhaúma class of the Brazilian Navy) and frigates (similar to the Niterói class of the Brazilian Navy)
0.?	Accuracy	Unassigned
0.?	Performance constraints	Unassigned
0.?	Countermeasures	Operating in a GPS-denied environment
0.?	Logistic aspects	Unassigned
0.?	Critical technologies	COTS (commercial-of-the-shelf) components can be used

Source: Table prepared by the authors, 2022.

5 THE ORDERING OF ZERO REQUIREMENTS

The origin of the zero requirements lies in the existence of immutable and guiding operational requirements for the entire ammunition development. However, since such requirements are established at a time prior to the formal start of the development project, situations in which compliance with one imposition makes it impossible, totally or partially, to comply with another may happen. Thus, an ordering between the zero requirements is suggested, based on the degree of inalterability of components associated with each category (Table 1).

This action aims to guide developers during solution feasibility studies (technical advice) and concept design. The intention is to report incompatibilities to the sponsoring organization, if they occur, and to present proposals for solutions aligned with priority operational needs, even before the start of development.

In the context of cruise missiles, typical examples of interrelated requirements are the range of the ammunition and the type of target it was intended to shoot down. The Tomahawk is a good element of comparison when looking at the ground attack (BGM-109C – Block II) and anti-ship (BGM-109B – Block I) versions, as shown in Table 2.

With the same dimensions and weight, the BGM-109B and BGM-109C versions of the Tomahawk show significant differences in range (Table 2). This lies in the need to employ, in the BGM-109B, a system (seeker) with radar technology to enable terminal navigation to moving targets at sea. Experience as a development engineer indicates that such devices have a high weight and occupy a large volume, factors that impair in-flight performance and limit the space allocated to fuel, respectively. Therefore, cruise missiles designed to neutralize moving targets tend to have a shorter range compared with those (similar) employed for destroying fixed (non-metallic) targets on the ground.

Table 2 – Comparison between range and target types for the Tomahawk, Harpoon, and Zvezda missiles.

Missile	Dimensions and Weight[1]	Range[2]	Target Type	Terminal Navigation System
Tomahawk (BGM-109C – Block II)[3]	L: 5.56 m D: 0.53 m W: 1,203 Kg	1,297 Km[4]	Fixed in the ground	Inertial + TERCOM + DSMAC
Tomahawk (BGM-109B – Block I)[5]	L: 5.56 m D: 0.53 m W: 1,205 Kg	465 Km[6]	Ships	Active radar
Harpoon (RGM-84F – Block ID)[7]	L: 5.3 m D: 0.34 m W: 785 Kg	240 Km[8]	Ships	Active radar
Zvezda Kh-35[9]	L: 4.40 m D: 0.42 m W: 620 Kg	130 Km	Ships	Active radar
Zvezda Kh-35U[10]	L: 4.40 m D: 0.42 m W: 670 Kg	260 Km	Ships	Active radar

1. The length of the missiles (without booster) is represented by the letter L, the diameter by the letter D, and the total weight by W. 2. Range values depend on the flight profile and speed. The data presented are based on typical values that characterize the ammunition. 3. Reference: Nicklas (2012). 4. Reference: Laur and Llanso (1995). 5. Dimensions and weight – Reference: Tomahawk... (2020). 6. Reference: Laur and Llanso (1995). 7. Dimensions and weight – Reference: RGM-84... (2016). 8. Reference: O'Halloran (2015). 9. Dimensions, weight, and range – Reference: Kh-35... (2018). 10. Dimensions, weight, and range – Reference: Kh-35... (2018).
Source: Table prepared by the authors, 2022.

The operational need for increased range on anti-ship missiles has been the subject of improvements from previous versions of the Harpoon. Introduced in 1991, the RGM-84F (Block ID) version enabled a range increase to 240 Km by increasing length to reach 5.3 meters (m) (O'HALLORAN, 2015) (previous versions, such as the RGM-84A has a range of 92.6 Km, with a length of 4.64 m (FULLER;EWING, 2016)). However, the version was discontinued in 2003, since the larger size limited the launch with the devices already in use by the surface and submarine fleet (O'HALLORAN, 2015).

Another relevant example of development aimed at improving range is the Russian Zvezda missile. The initial version makes it possible to shoot down ships 130 km away from the launch point, whereas the Kh-35U model allowed double this value, by replacing the cruise engine; reallocating the internal space for greater fuel storage; and using a new lighter seeker with greater sensitivity (Kh-35..., 2018). Thus, the external dimensions were not modified, maintaining the means of launch for both versions.

The previous cases demonstrate the importance of the sponsoring organization establishing an order of priority for the zero requirements. If there is a conflict of compliance between requirements, there are two possibilities to follow: the correction process (modification) occurs in items with a lower immutability index or the decision-making authority chooses, after technical advice based on feasibility studies, to change or suppress some zero requirement that causes

the incompatibility. Based on the Zvezda missile, the means of launch assumes a higher rate of immutability (requirement 0.1) and thus has not undergone remodeling. The range requirement was met with changes in internal components of the ammunition (without alteration of the external dimensions).

With the example from Table 1, two fictitious scenarios are possible (Table 3). The first, scenario A, has the means of launch category with the highest immutability index (lowest possible numbering, i.e., 0.1), whereas the reach category has a higher numbering, for example, 0.3. The information provided by the decision-making authority indicates that any work to be carried out to ensure the desired range (or compliance with any other zero requirement) should not take place in the means of launch, but in another internal component of the ammunition (development of a new and specific fuel, change of the engine for models with lower consumption, structural weight reduction, etc.). Scenario B, in turn, lists the range category with numbering 0.1, which denotes the obligation to reach the required value, even if some adaptations are implemented in the means of launch, such as changes in the external dimensions of the ammunition (always with the proper authorization of the decision-making authority).

Table 3 – Examples of possible scenarios with different zero requirement orderings.

Scenario A		Scenario B	
Numbering	**Category**	**Numbering**	**Category**
0.1	Means of launch: ASTROS System AV-LMU	0.1	Reach: 200 Km
0.2	Target type: moving targets at sea	0.2	Target type: moving targets at sea
0.3	Reach: 200 Km	0.3	Means of launch: ASTROS System AV-LMU

Source: Table prepared by the authors, 2022.

6 THE WORDING OF ZERO REQUIREMENTS

The specialized literature in systems engineering recommends writing a project requirement as a simple sentence, expressed with the verb should, capable of informing the indispensable (characteristics or functionalities) to enable the development of a solution by the team of engineers (KOELSCH, 2016).

This article proposes to add four new information fields to the single, simple text that characterizes a requirement. The purpose is to provide additional data for a better understanding of the sponsoring organization's desires and expectations. The practice of working on smart ammunitions developments reveals that the process of defining and using the requirements is recursive and interactive with the decision-making authority, and data complementary to the text of the requirement contribute to reaching a robust final solution that adheres to the initial objectives of the sponsor. Thus, including the justification field is recommended, with a description of the motivations that led to the data present in the requirement.

Also, incorporating the fields test methodology (test method that should be used to prove the requirement), estimate of the number of specimens (prototypes necessary to prove the requirement), and basic acceptance criterion (criterion to evaluate the requirement) is suggested. This allows the technical leader of the project a better knowledge of the material and provides managers with a position on forecasting costs and deadlines demanded.

Table 4 was assembled to provide an example of how to fill in the proposed fields to complement the design requirements of defense systems.

Table 4 – Example of zero requirements wording with the inclusion of information fields.

Field	Content
Numbering[1]	0.1
Requirement[2]	The cruise missile is expected to be launched from the AV-LMU vehicle of the ASTROS 2020 system.
Justification[3]	Unlike other competing missile launchers, the cruise missile should be launched from the same platform on which the conventional rockets of the ASTROS system are launched, greatly facilitating the logistics of the missile, especially regarding the components of the launch vehicles[4]. Therefore, no changes should be implemented in the mechanical, hydraulic, and hardware systems of AV-LMU. Only software updates may be considered.
Test methodology[5]	Flight test.
Estimated number of specimens[6]	A functional prototype of the cruise missile.
Basic acceptance criteria[7]	Missile fulfilled all its functions (mechanical, electronic, etc.) after being fired from an AV-LMU vehicle in conjunction with the other vehicles of the ASTROS system.

[1,2,3,5,6,7] Prepared with the sponsoring organization and team of engineers. [4] Reference: Dantas (2021).

Source: Table prepared by the authors, 2022.

Although Table 4 presents an example of wording for zero requirements, the same procedure is recommended for all other technical, logistical, and industrial requirements of the project.

7 CONCLUSION

The task of developing requirements in complex systems development projects plays a vital role in obtaining a solid final solution capable of meeting the initial expectations and needs of the sponsoring organization. Experience in the development of smart munitions, such as cruise missiles, reveals that the greater the investment of time and resources in the process of building the requirements, the less the possibility of problems related to time delay and increase of the costs initially planned.

A significant addition to this process is the joint work between the user and the engineers/technical managers, even before the formal start of the development project. A team of military engineers, with experience in the subject of interest, can provide in-depth analyses and

solutions to technically advise the authorities in decision-making involving engineering projects related to national defense.

For this purpose, an interaction between the sponsoring organization and development engineers is mandatory still in the phase prior to the elaboration of the CONDOP SMD F Ter.

The relevance of this constant joint work is also noted during the production of operational requirements, since they should, preferably, contain only information that characterizes the context of employment, avoiding, except in specific cases, texts with numerical data that may direct a specific technical solution, either to part or to the entire Military Employment System or Material (SMEM).

In this sense, adopting a new class of requirements aims to identify the constraints that will be the basis for all the construction of the engineering project. Given this importance, it is recommended that the zero requirements (and the relative ordering between them) be condensed into a document of their own, attached to CONDOP SMD F Ter.

Also, including new fields of information, adhered to the text of the requirement, allow a better knowledge of the desires and objectives for the SMEM, in addition to providing managers with an initial forecast of deadlines and material, financial, and human resources needed.

Finally, the proposals presented for elaborating requirements in defense systems projects contribute to achieving a final solution (SMEM) adhering to the initial operational demand, with estimated and more adequately controlled deadlines and costs.

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The Structural Equation Modeling with Partial Least Squares: a statistical technique for Defense and International Security studies

El Modelado de Ecuaciones Estructurales con Mínimos Cuadrados Parciales: una técnica estadística para estudios de Defensa y Seguridad Internacional

Abstract: Partial least squares structural equation modeling (PLS-SEM) is a robust multivariate statistical technique that adjusts small samples and enables researchers to simply, systematically, and comprehensively answer a series of interrelated questions. This statistical technique was explicitly created to be used in the social sciences, whose studies sometimes lack large samples and new theories can be formed from the constant social changes. It achieves this by modeling the relationships between multiple dependent and independent constructs, considering different types of measures and various variables. This methodological study aims to describe the statistical technique in question, describing the assumptions of the method, its procedures, quality parameters, and limits. An analysis example illustrates the article using the SmartPLS software. In conclusion, this study brings reflection on the potential use of this statistical technique for International Security and Defense research.

Keywords: multivariate statistics; prediction; SmartPLS; constructs; structural models

Resumen: El modelo de ecuaciones estructurales de mínimos cuadrados parciales (PLS-SEM) es una sólida técnica estadística multivariada que se ajusta a muestras pequeñas y permite a los investigadores responder a una serie de preguntas interrelacionadas de manera simple, sistemática y completa. Esta técnica estadística fue creada explícitamente para ser utilizada en las ciencias sociales, donde los estudios no siempre cuentan con muestras amplias y se pueden formar nuevas teorías a partir de los constantes cambios sociales. Lo logra modelando las relaciones entre múltiples constructos dependientes e independientes, considerando diferentes tipos de medidas y diversas variables. Este ensayo metodológico tiene como objetivo presentar la técnica estadística en cuestión, describiendo los supuestos del método, sus procedimientos, parámetros de calidad y límites. Un ejemplo de análisis ilustra el artículo utilizando el software SmartPLS. En conclusión, el articulo trae una reflexión sobre el uso potencial de esta técnica estadística para la investigación en Seguridad y Defensa Internacional.

Palabras clave: estadística multivariada; predicción; SmartPLS; construcciones; modelos estructurales

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1 INTRODUCTION

Structural equation modeling (SEM) is a relatively new second-generation statistical technique that enables researchers to explain the interrelations between multiple constructs or latent variables indirectly measured by observable variables by combining factor analysis and multiple regression (HAIR *et al.*, 2014).

It differs from other analyses such as multiple regressions, multivariate analyses of variance, discriminant analyses, and other multivariate analyses by considering all dependent and independent variables at the same time, rather than focusing on the individual relations between them. This enables structural equation modeling to achieve its main objective: to expand researchers' capacity to propose and confirm new theories (HAIR; ANDERSON; BABIN, 2019).

SEM has two types: covariance-based structural equation modeling (CB-SEM) and partial least squares structural equation modeling (PLS-SEM). Based on Jöreskog's work, CB-SEM was first developed in the late 1960s and early 1970s, becoming popular by the analysis software he also created, i.e., the LISREL system (MARÔCO, 2021). CB-SEM first aims to confirm or reject theories by verifying systematic relationships between empirically measured multiple variables. CB-SEM confirms proposed theories by estimating a new covariance matrix from field data that is statistically indifferent from an original covariance matrix established in the theoretical proposition of the interrelations model. CB-SEM employs a maximum likelihood estimator (or equivalents) to estimate the relations between constructs in a covariance matrix. Although some estimators based on polychoric equations compensate for the nonparametric distribution of data, the model assumes that they adhere to a normal distribution and were collected by a minimally intervallic measurement. CB-SEM analyzes reflective models but accepts non-recursive (mutually reciprocal) and recursive (unidirectional) relations between them (HAIR *et al*., 2014, 2019; HAIR; RINGLE; SARSTEDT, 2011; KLEM, 2006; SCHUMACKER; LOMAX, 2004).

PLS-SEM configures the recommended method if either CB-SEM assumptions are unable to be met, research aims to predict (rather than confirm) structural relationships, or formative models are predicted in theory. PLS-SEM, conceived for social science research, appeared in the late 1970s — in Wold's work (Jöreskog's advisor) above all — later receiving Lohmöller's (1989) developments. PLS-SEM uses the ordinary least squares method to estimate the relationships in the model and minimize the unexplained variance (errors) of its dependent (endogenous) variables. Its iterative algorithm separately solves measurement model blocks and estimates the path coefficients of the structural model. Due to its aim to expand the explained variance of endogenous variables, PLS-SEM is the first technique researchers consider when they wish to develop new explanations, i.e., new construct predictions to support a new theories (HAIR *et al*. 2014; HAIR; RINGLE; SARSTEDT, 2011; VINZI *et al*., 2010).

Since the PL-SEM ordinary least squares estimator is distribution-free, data can either adhere to a normal, random or a linear distribution as the technique deals well with asymmetry and kurtosis deviations. Analyses can measure data by ratios, intervals (such as Stapel scales or semantic differentials), orders (such as Likert scales), and dichotomies (yes/no scales), the latter with some restrictions. It works with both formative and reflective measurement models, but only with recursive relationships between latent variables. As it requires neither normal distribution, large samples nor randomly collected linear data, PLS-SEM is called soft modeling — which refers neither to its quality, power nor criterion (VINZI et al., 2010).

2 CAN PLS-SEM BE USEFUL IN DEFENSE AND INTERNATIONAL SECURITY STUDIES?

International security and defense studies deal with political decisions to balance international power and maintain peace.

Individuals make these decisions in complex scenarios with many variables in their elaboration since they are, above all, human decisions. Thus, understanding them requires considering the multiplicity of their causal factors. Qualitative approaches describing these phenomena and evaluating their dimensions can primarily identify and understand them. PLS-SEM offers a complementary analytical step since it can predict the effects of the considered variables with empirical data. Qualitative research can evaluate relations between variables, whereas quantitative research, the extent to which variables can predict each other and if this occurs at random. Thus, researchers can predict changes in scenarios, conditions, and attitudes since decisions (endogenous variables) always depend on their context.

We found some research in the area that used this multivariate statistical technique to investigate international security and defense issues, such as logistics chain (KOUVELIS; MUNSON, 2004; RAHIMI SHEIKH; SHARIFI; SHAHRIARI, 2017), diplomacy (AKBARIYE; VAZIFEDOUST; SALEH ARDESTANI, 2018), human trafficking (RUDOLPH; SCHNEIDER, 2013), voting behavior (CWALINA; FALKOWSKI; NEWMAN, 2010), patriotism and nationalism (KARASAWA, 2002), and global strategies (BOUQUET; BIRKINSHAW, 2011), indicating that the area has accepted this technique. However, SEM seems to be less explored than other methodological alternatives.

This study aims to describe this type of structural equation modeling (PLS-SEM) to military science, defense, and international security researchers. Thus, it offers its premises, procedures, and quality parameters. We systematized this information from classic and up-to-date books and articles we cite throughout. We organized this information to conceptualize its constituent elements, describe its estimation phases (including parameter adjustment), and show criticisms to it. To better depict the technique, we describe an example of an analysis made in SmartPLS.

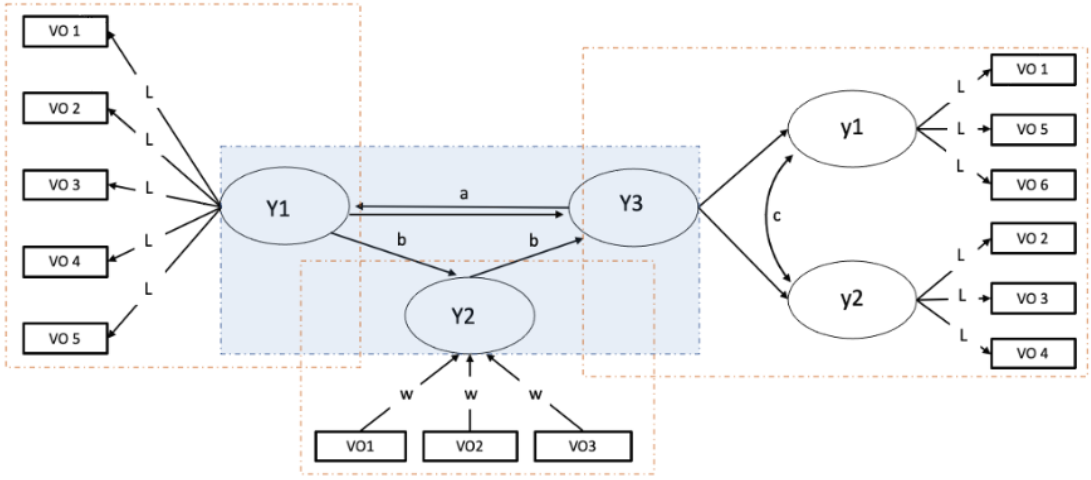
3 THE STATISTICAL TECHNIQUE IN QUESTION: PLS-SEM ELEMENTS

PLS-SEM operates by estimating interrelations between latent variables (constructs). Latent variables (e.g., safety perception) are hypothetical, i.e., unable to be directly measured. However, researchers can infer them by selected indicators, such as safety perception index items, which the PLS-SEM calls observable variables. Graphs can represent PLS-SEM models, conventionally expressing latent variables by ellipses and observed variables by rectangles (Figure 1).

The relationships established between the variables determine which the model deems dependent and independent. SEM calls independent variables exogenous and dependent variables, endogenous. Exogenous variables predict other variables/constructs in the theoretical model. It determines them outside it without specifying their causes. Endogenous variables results from at least one prediction relationship. Researchers can distinguish which exogenous variables predict each endogenous variable by relying on theory and/or their own previous experiences (HAIR; ANDERSON; BABIN, 2019; HERSHBERGER; MARCOULIDES; PARRAMORE, 2003; KLEM, 2006).

We should also mention that SEM actually consists of a structural model and a measurement model (Figure 1).

Figure 1 – Example of a structural measurement model



Source: Prepared by the authors, 2022.

The three orange hatched areas above highlight outer models. They deal with the relationships between observable and latent variables. They can contain first-order latent variables (such as Y1), which explain all observable variables in a single dimension. They may also contain second-order latent variables (Y3), which explain first-order latent variables (y1 and y2), directly connecting to observable variables and representing partial theoretical abstractions to form upper constructs (Y3) (HAIR *et al*., 2014; VINZI *et al*., 2010).

In this model we define its measurement theory for each latent variable, i.e., whether the latent variable will be evaluated in a reflexive or formative way. Graphically, the arrows go from latent variables to observable variables in the reflective measurement model (Y1, y1, and y2). In this type of model, constructs affect indicators, i.e., based on theoretical definitions, researchers seek elements for observation. Each latent variable affects observable variables differently and can be measured by factor outer loadings (λ). Observable variables tend to be correlated with each other, configuring more palpable manifestations of latent variables. For example, international defense capacity manifests itself as diplomatic skill, trade relation quality, power balance roles, and geopolitical importance.

On formative measurement models, observable variables are characteristic of latent variables. Each observable variable composes a portion of the construct, represented by outer weights (ω). A small change in one of them alters the construct, e.g., combat capacity consists of the amount of armored, trained men; mass destruction weapons; fighter aircrafts; and available ammunition. In the graphical representation above (Figure 1), arrows come out of indicators (equivalent to observable variables in formative models) to manifest variables or domains (equivalent to latent variables in formative models; Y2) (BECKER; KLEIN; WETZELS, 2012; HAIR *et al*., 2014, 2019; VINZI *et al*., 2010).

Structural (or inner) models predict the relations between the studied constructs (the blue area in Figure 1). In structural models, researchers define how variables relate to each other. Their structural coefficients (β) describe the strength and direction of this relation. Graphically, relations are established from left to right. The left margin of the image refers to exogenous variables (Y1) — which only emit arrows —, whereas its right margin refers to endogenous variables (Y3) — which receive path arrows —, and some that receive and emit arrows — also called endogenous (Y2) — but that may also include moderating variables depending on the approach (HAIR; RINGLE; SARSTEDT, 2011; VINZI *et al*., 2010).

Arrows indicate the type of relation between latent and observable variables. The unidirectional arrows (b) in Figure 1 indicate a recursive relation between them, whereas bidirectional arrows (a) indicate a non-recursive relation between variables, i.e., a mutual and reciprocal relation. Curved bidirectional lines (c) represent the correlation between the latent variables in the model (GARVER; MENTZER, 1999; HAIR; ANDERSON; BABIN, 2019; HERSHBERGER; MARCOULIDES; PARRAMORE, 2003).

During the definition of structural models, researchers delimit their theoretical propositions and propose to answer questions such as: how can we explain the studied factor relations? What influences them significantly? What would be a valid prediction? These questions should find support in the research theoretical framework – even if it is yet to be fully defined. We should mention that all mathematical analysis on data with this statistical method will be in vain in the absence of theoretical support. We must keep this assumption in mind.

4 THE PLS-SEM ESTIMATION PROCESS

More current approaches propose that the decision process to estimate PLS-SEM takes place in six stages (HAIR; ANDERSON; BABIN, 2019) divided into three phases: (i) research preparation; (ii) model analysis and adjustment; and (iii) the further exploration of results.

Today, several alternatives to process data and perform PLS-SEM analyses with the aid of software are available (e.g., SmartPLS; MPlus; PLS-Graph, and the R PLS package). Some formulas in this section aim to facilitate readers' understanding of the concept. In short, researchers must choose their measurements, determine their predictions, collect data, program the software, interpret their results for structural measurement models, and further explore their data, reflecting the six stages we will describe next, except for software (programming), whose choice remains at researchers' discretion.

4.1 Phase 1: research preparation

The first stage deals with defining research objectives and selecting model constructs. As for objectives, PLS-SEM is the ideal multivariate statistical method when researchers wish to investigate multiple relations in constructs for cases in which the underlying theory is yet vague, i.e., in the absence of clear predictive relations, when researchers want to create a new theoretical perspective from the empirical evidence stemming from evaluating possibly related constructs; or when research problems deal with "how," "why," and "when" questions as PLS-SEM basically accepts all measurement levels (HAIR; ANDERSON; BABIN, 2019).

Then, researchers should choose the proper evaluation instruments to generate data. Measurement instruments with reflective models are evaluated for their quality based on their validity and reliability metric evidence. Those based on formative models have their quality evaluated by their factor weights and collinearity between their indicators. Keeping this in mind is of special relevance at this stage. After all, researchers can only test prediction hypotheses between constructs (the ultimate goal of PLS-SEM) if the way to measure them offers reliable data and properly evaluates the investigated construct.

The validity evidence of a measure indicates what is being measured (construct representation) and what inferences can be made from it (score interpretation) (URBINA, 2004). They must be considered in the application context. Thus, validity evidence, rather than belonging to the instrument, appropriates the measure in a given country for a certain population (HURTZ; BANDEIRA; TRENTINI, 2015).

Classically, up to 31 types of validity can be distinguished (PASQUALI, 2007), of which we highlight construct validity, which aims to experimentally show that the instrument indeed measures what it aims to measure (BROWN, 2000). Construct validity have three subtypes: discriminant validity (evidence of distinct factors in the constitution of the construct), convergent validity (evidence that the selected variables represent well each unifactorial construct factor), and nomological validity (evidence of association between

constructs, observable variables, and constructs and observable variables) (NUNNALLY; BERNSTEIN, 1994; PASQUALI, 2007; URBINA, 2004). Construct validity can be verified by different statistical tests, but minimally, the definition of the factorial structure (how items are organized into factors and how factors are identified) is defined by what is necessary to consider as primary evidence of construct validity (MARÔCO, 2021).

Reliability, on the other hand, refers to evidence that the instrument consistently performs measurements without errors (i.e., score fluctuations are irrelevant to what is being measured) (COZBY, 2001; URBINA, 2004). The scales researchers must choose in this first stage must show evidence of previous validity and reliability.

In formative models, researchers should check the hypothesis of evidence of no multicollinearity (correlations between indicators) and whether indicator factor weights (w) are relative or absolutely significant for measures (HAIR *et al*., 2017; ROBERTS; THATCHER, 2009).

The second stage is the study design, which defines the sample size to be collected and missing data treatment. Sample size estimation must aim to preserve the statistical power of the method — i.e., the ability of tests to identify correct answers — which must be at least 80% (COHEN, 1992). This calculation should also consider model complexity — the number of latent variables, observable variables, and estimated causal relations — and sample heterogeneity (HAIR; ANDERSON; BABIN, 2019; VINZI *et al*., 2010).

Sample size estimation has some available options. One of the first rules for setting the minimum required sample size was called the 10×-rule (BARCLAY; HIGGINS; THOMPSON, 1995), which determines that the number of indicators of the largest formative model or the largest number of arrows (paths) directed to a given construct in the model be multiplied by 10. This rule has received serious criticism (KOCK, 2018; KOCK; NADAYA, 2018) and is currently deemed as poorly (if at all) adequate (KOCK, 2018; KOCK; NADAYA, 2018). Alternatively, recommendations suggest that minimum sample sizes be estimated by software such as G*Power[1] (using its calculations to test regressions) or alternative methods, such as the inverse square root (which uses the inverse square root of a sample size to estimate standard errors) and the gamma-exponential method (which corrects the gamma and exponential smoothing function applied to a previous method) (KOCK; NADAYA, 2018). Other rules that consider significance levels and explained variables can also estimate sample size (COHEN, 1992). Researchers should keep in mind that the more heterogeneous their population, the greater the required sample size to properly evaluate the idiosyncrasies of the evaluated manifestations (HAIR; RINGLE; SARSTEDT, 2011; HAIR *et al*., 2012; HAIR; ANDERSON; BABIN, 2019; VINZI *et al*., 2010).

Researchers should carefully consider missing data as PLS-SEM is quite sensitive to them. Listwise deletion configures the most judicious way to do so, i.e., excluding subjects (be it

1 Free software, available at: http://www.psycho.uni-duesseldorf.de/abteilungen/aap/gpower3/. It has the advantage of considering effect sizes and sampling power to estimate sample numbers.

States or individuals) for which researchers' databases lack information of some variable. As listwise deletion potentially shrinks databases, it may often be far from ideal — despite being the most judicious choice. After data collection, researchers must also evaluate missing data patterns to evaluate if they have systematically failed to answer some observable variable. If so, they should consider measurement biases (HAIR; ANDERSON; BABIN, 2019).

In the third stage, researchers more clearly define which hypothesis they will test in their research. This process begins with researchers' theoretical propositions based on the relations between the studied constructs — the first definition of the structural model. This stage has three critical elements: (i) researchers should know the investigated topic to determine which variables are endogenous and exogenous; (ii) they should indicate the dependencies and predictive or causal relations in the literature among latent variables; and finally, (iii) they should employ the measurement instruments they chose in the first research stage with the pertinent metric quality evidence (whether formative or reflective) for the data they collected in the country in which they are to conduct their study.

Researchers define their structural theory and prediction paths at this point in analysis planning. A literature review on their study constructs with evidence on their sample will support these decisions as will researchers or their colleagues' previous studies (HAIR; ANDERSON; BABIN, 2019; VINZI *et al*., 2010). Researchers must constitute a theoretical background to support their predictions.

Researchers should go to the field after deciding that PLS-SEM statistical analysis meets their objectives and choosing what measures, sample, and theoretical assumption they will use to collect data. The following stages already consider that researchers have collected data and are now testing the metric fit of their instruments to their sample and exploring the significance of the proposed causal relations.

4.2 Phase 2: analysis and adjustments to measurement and structural models

The fourth stage consists of evaluating measurement models. This process changes if the chosen assessment instruments are reflective or formative. Reflective instruments require researchers to evaluate the evidence of validity and reliability of their sample measurements. Researchers must first observe the factor loadings of their observable variables, which should ideally equal or exceed 0.71, indicating about 50% of the variation in latent variables. Close values are to be tolerated as long as they compromise neither reliability nor validity, but it is highly recommended to eliminate those below 0.40. Researchers can eliminate some observable variables from their measurement models to improve the quality of their measurements, a common procedure. When they eliminate all observable variables with very low factor loadings (< 0.40), they must continue to refine their measurements — including further exclusions — considering their impact on the measurement reliability and validity (HAIR *et al*., 2009, 2014, 2019).

The evaluated PLS-SEM reliability refers to internal consistency, i.e., the internal coherence of the indicators in relation to latent variables. PLS-SEM evaluates construct

reliability by the "degree to which the indicators of a latent construct are internally consistent with each other" (HAIR *et al*., 2009, p. 467). The following formula estimates construct reliability:

$$\text{construct reliability} = \frac{\left(\sum_{i=1}^{n} \lambda_1\right)^2}{\left(\sum_{i=1}^{n} \lambda_1\right)^2 + \left(\sum_{i=1}^{n} e_i\right)}$$

in which ∑ refers to summation; λ_i, the standardized factor loading of observable variables of a latent variable; and *i*, the measurement error of each item of the latent variable, estimated as 1 (observable variable reliability).

Moreover, researchers can evaluate internal consistency with other tests and add reliability evidence to their measurements. The Cronbach's alpha test is the classic test to generate this evidence, producing a Cronbach's alpha coefficient (α) from the correlations between observable variables. However, this indicator has been widely questioned as an adequate measure for non-interval scales or an accurate representation of the internal consistency of measurements (SIJTSMA, 2009). Some still advocate its use, and the test tends to be maintained since it can interpret accumulated evidence (TAVAKOL; DENNICK, 2011). Researchers can employ other tests to correct the deviations the Cronbach's alpha test may have for non-interval scales, such as the ordinal alpha test, omega, and the greatest lower bound test (PETERS, 2014). All reliability tests we mentioned recommend values above 0.70, tolerating those above 0.60 (HAIR; ANDERSON; BABIN, 2019).

Researchers should then evaluate construct validity, generating evidence of convergent and discriminant validity. A measurement error variance below the captured variance constitutes convergent validity, indicating the extent to which observable variables converge in the construct. This is established with the help of the average variance extracted (AVE) by the formula:

$$\text{Average variance extracted} = \frac{\sum_{i=1}^{n} \lambda_j^2}{n}$$

in which ∑ refers to summation;. λ_i, the standardized factor loading of the observable variables in the latent variable, and *n*, the number of items in each factor. Values above 0.50 are considered adequate (HAIR *et al*., 2014, 2019).

Discriminant validity, in turn, points to the extent to which a latent variable differs from another. It can be evaluated by cross-correlations analysis, the Fornell-Larcker criterion, and the heterotrait-monotraitrat ratio of correlations (HTMT) test. Regarding cross-factor loading analysis, factor loading indicators in the assigned construct should exceed all loads of other constructs (HAIR; RINGLE; SARSTEDT, 2011).

The Fornell-Larcker criterion (FORNELL; LARCKER, 1981) compares the square root of the AVE with construct correlation. The logic underpinning this indicator is that latent variables should better explain the variance of their own indicators rather than that of other latent variables. Therefore, the square root of the AVE of each construct must exceed the correlations with other latent constructs (HAIR *et al*., 2014).

The HTMT test is the most recent alternative to investigate discriminant validity. Henseler, Ringle, and Sarstedt (2015) showed its superior performance in comparison to the two aforementioned alternatives by studying the Monte Carlo simulation and recommending its use. HTMT values close to 1 indicate a lack of discriminant validity. Some authors suggest a 0.85 (KLINE, 2015) and even 0.90 limit (TEO; SRIVASTAVA; JIANG, 2008). For Henseler, Ringle, and Sarstedt (2015), values must reside between -1 and 1 to evince discriminant validity. Lower values elicit more important evidence of discriminant validity.

Adjusting measurement instruments to meet reliability and validity criteria mainly involves eliminating items with very low loadings (< 0.40) and deciding to eliminate or maintain items those between 0.40 and 0.70. Researchers may maintain items that showed no negative impact on validity and reliability indicators with factor loadings between 0.69 and 0.41 to better preserve the content validity of their measurements (HAIR; ANDERSON; BABIN, 2019).

However, in the presence of instruments with formative measurement models, researchers should be aware that evaluating the quality of the measurement model containing these instruments involves other parameters since those described so far are largely based on correlations between observable variables. Thus, as indicators are expected to be independent or, at most, weakly correlated in formative models, the aforementioned measures to evince validity and reliability should be avoided in this case (ROBERTS; THATCHER, 2009). Analyses should focus on determining (i) unwanted correlations between two or more indicators — collinearity; and (ii) the indicator factor weights (w) (HAIR *et al*, 2017).

A correlation between two indicators creates collinearity — which is problematic in this model as it assumes that each indicator contributes independently to the construct (if more indicators are involved, this situation is called multicollinearity). Collinearity (or multicollinearity) increases standard errors and decreases the ability of regressions to correctly estimate factor weights — both in their value and in their significance. This is particularly concerning for small samples, in which standard errors are usually large (HAIR *et al*., 2014).

Researchers can check for multicollinearity by estimating tolerance (TOL). TOL evaluates how much the variance of an indicator remained unexplained by other indicators in the same latent (or preferably, manifest) variable. TOL is estimated as follows:

$$\text{TOL} = R^2_{x1}$$

in which R^2_{x1} refers to the v*ariance proportion of* x_1 associated with other indicators. Each indicator in the model has a TOL value which must be estimated. A measure related to TOL is the variance inflation factor (VIF), which can be estimated as:

$$\text{VIF} = {}^{1}/_{TOL}$$

These two collinearity measures can analyze retention criteria in instruments, although only reporting the VIF has become the most common practice. Values < 5 are deemed

acceptable and < 3.3, preferable (HAIR *et al*., 2017; DIAMATOPOULOS; SIGUAW, 2006). For indicators exceeding these values, researchers should consider eliminating them from their model since other indicators explain a large portion of their variance. However, they must have some certainty that this exclusion will fail to affect the constitution of the manifest variable (BIDO *et al*., 2010; LATAN, RAMLI, 2013).

The factorial weight of indicators (ω) evaluate the contribution of each indicator to the manifest variable. It derives from the multiple regression of manifest variable (dependent variable) and indicators (independent variables) scores. Ω is standardized so it can be compared with others from the same manifest variable, enabling researchers to assess its relative importance in the formation of constructs (HAIR *et al*., 2014). To be important, ω must be significant and preferably (though not necessarily) > 0.50. When ω is insignificant but has a high factor loading (λ) (> 0.50), the indicator should be interpreted as absolutely important (i.e., the information it gives is important, but it fails to consider other indicators). In this situation, the indicator would usually be kept in the formative model but when indicators have non-significant ω and λ < 0.50, researchers must decide whether to retain or exclude them by examining their theoretical relevance and the overlap of potential content with other indicators in the same construct (HAIR *et al*., 2014).

The fifth stage begins when researchers can examine their structural model after ensuring validity, reliability, and/or collinearity, and the value and significance of the factorial weights of measurement model indicators. The first step of the fifth stage is to evaluate the collinearity between exogenous constructs (predictors). The variance inflation factor (VIF) is calculated for each latent predictor variable and, as a rule, higher VIF values indicate collinearity. Researchers can also infer collinearity by a bivariate correlation test between latent predictor variables, seeking correlations lower than 0.50 to indicate absence of collinearity. In such a case, researchers may create a second-order factor for the construct in question to deal with this problem without losing variables in their model (HAIR; ANDERSON; BABIN, 2019).

Next, researchers can deal with actual prediction relations (the structural model). The coefficient of determination (R^2) ranges from 0 to 1 and higher values indicate greater ability to explain structural models and thus better predict endogenous variables. In general, values equal to 0.25; 0.50, and 0.75 indicate weak, moderate, and substantial effects, respectively. However, in the social sciences, the 0.02; 0.13, and 0.26 limit values are recommended to interpret variables as weak, moderate, and substantial, respectively (COHEN, 1988; HAIR *et al*., 2014).

Effect size (f^2) represents the change to the coefficient of determination by omitting an exogenous variable from the model, and may be interpreted as how useful each construct is to adjust the model. Values equal to 0.02; 0.15, and 0.35 are considered as small, medium, and large effects of an exogenous latent variable and values below 0.02 indicate no effect (i.e., no predictive capacity) (HAIR *et al*., 2014; 2019).

The next step is evaluating the predictive power of the model (Q^2; Stone-Geisser indicator). As a rule, its value is obtained by blindfolding, considering the cross-redundancy approach available in most PLS-SEM analysis software. Values equal to or above zero

for each endogenous construct of the model indicate an acceptable predictive accuracy of the model, and higher values indicate greater predictive accuracy (HAIR *et al*., 2014, 2019; VINZI *et al*., 2010).

Finally, researchers should evaluate the size and significance of predictive relations by structural coefficients (graphically represented by arrows in the model and which conceptually explain prediction relations). Structural coefficients must be significant — if $p < 0.05$, $t > 1.96$, and confidence intervals without zeroes. Values greater than these additionally indicate collinearity in the model (Table 1). Structural coefficient values must be interpreted in the light of theory to assess their importance, whereas their mathematical interpretation should follow the betas (β) of simple or ordinary linear regressions. Values that can be considered acceptable depend on model complexity and research context (HAIR; ANDERSON; BABIN, 2019; RINGLE; SILVA; BIDO, 2014).

Table 1 — Summary of Smart PLS adjustments

INDICATOR	PURPOSE	REFERENCE VALUES/CRITERIA	REFERENCES
VIF	Multicollinearity evaluation.	VIF < 5 VIF < 3.3 (stricter)	HAIR *et al*. (2017)
AVE	Convergent validity evaluation.	AVE 0.50	HENSELER; RINGLE; SINKOVICS (2009)
HTMT	Discriminant validity evaluation.	HTMT < 0.85	HAIR *et al*. (2019)
Composite reliability	Model reliability evaluation.	CC 0.70	HAIR *et al*. (2017)
Student's t-test	Correlation and regression significance evaluation.	t > 1.96	HAIR *et al*. (2017)
Pearson's coefficient of determination (R^2)	Evaluation of the variance portion of endogenous variables, explained by the structural model.	For the social and behavioral sciences, an R^2 = 2% is classified as a small effect, an R^2 = 13%, as medium effect, and an R^2 = 26%, as a large effect.	COHEN (1988)
Cohen's indicator (f^2)	Evaluation of how much each construct is useful to adjust models.	Values of 0.02, 0.15, and 0.35 are considered small, medium, and large, respectively.	HAIR *et al*. (2017)
Stone-Geisser indicator (Q^2)	Evaluation of the accuracy of adjusted models.	$Q^2 > 0$	HAIR *et al*. (2017)
Structural coefficient (β)	Causal relation evaluation.	Interpretation of values in the light of theory.	HAIR *et al*. (2017)

Source: Ringo, Silva, and Bido (2014); Hair *et al*. (2017, 2019)

4.3 Phase 3: Further exploration of results

In the sixth stage of the PLS-SEM estimation process, researchers can do additional analyses to better explain, specify, or even interpret their model. We highlight two possible analyses: the investigation of sample heterogeneity and the presence of mediating or moderating variables.

Multigroup analysis can evaluate differences between sample subgroups formed from categorical variables (e.g., continent, government system, etc.). This is called observed heterogeneity. The subsamples by which heterogeneity is to be investigated must meet power and sampling significance criteria (i.e., they must exceed the calculated minimum, considering the studied model). The structural coefficients for each sample will be estimated and the variation between them analyzed. No variation ($p > 0.05$) will suggest the absence of sample heterogeneity. The approach to these analyses is called PLS-MGA (PLS — multigroup analysis) and is built into the most common software.

Researchers can also evaluate unobserved heterogeneity — groups differ by a characteristic researchers failed to observe. It can be approached by the probability of sample participants belonging to segments (subsamples) and by differences in segment structural coefficients. Researchers must predict the number of possible segments from the ratio between their total sample and the minimum required sample. The number of segments will be the smallest integer value closest to this ratio. The finite mixture partial least squares (FIMIX) configures a specific method to estimate structural model heterogeneity. Another approach is prediction-oriented segmentation (PLS-POS), which also observes heterogeneity in structural and measurement models but with the advantage that it does so for models with formative and reflective variables and generates information about explained variance (R^2) by forming homogeneous groups, reassigning observations (if it improves the quality criteria of the models), and working with specific distance measures for formative variables. Hair *et al* (2017) recommend that these two methods be used together, starting with FIMIX and segment analysis. Failure to reject the existence of heterogeneity in structural models suggests continuing analyses with the PLS-POS. A third option is response-based procedure for detecting unit segments (REBUL-PLS), which analyzes heterogeneity in structural and measurement models with reflective variables, observing model and latent variable residuals (HAIR *et al.*, 2017, 2019).

In cases in which a variable both predicts an exogenous variable and is explained by an endogenous variable (Y2 in Figure 1), researchers should investigate whether that variable mediates or moderates the prediction of exogenous variables over endogenous variables. Moderating variables contaminate the predictive relations between independent and dependent variable and must then be controlled as it affects the strength and direction of the prediction (for example, between the need to deter an enemy and actually doing so, this outcome can be moderated by confidence in combat ability). Mediating variables, in turn, explain the relation process between two variables, i.e., an intermediary between independent and dependent variables (for example, sleep quality can affect combat performance as a function

of cognitive alertness). Knowing whether the variable has a mediating or moderating effect enables the evaluation of the total effects between constructs, more completely evaluating predictions (HAIR *et al*., 2017, 2019).

5 LIMITATIONS AND CRITICISMS

Although the PLS-SEM can deal with data of different measurement levels; data that fail to adhere to normal distribution; relatively small samples; and relatively poor theoretical support — thus contributing to the maturation of the investigated theory —, the method has received criticisms.

First, this structural model forbids non-recursive relations (reciprocal influence between variables). If researchers' theoretical prediction or previous evidence indicates that considering this relation is important to the model, researchers should consider using CB-SEM, rather than PLS-SEM (HAIR *et al*., 2014, 2017, 2019; VINZI *et al*, 2010).

Secondly, it is stated that the PLS-SEM estimates are inefficient and potentially biased when compared with CB-SEM measurements (e.g., MARCOULIDES; SAUNDERS, 2006; MCINTOSH; EDWARD; ANTONAKIS, 2014; RÖNKKÖ, 2014; RÖNKKÖ; EVERMAN, 2013). The central argument supporting these criticisms is that PLS-SEM estimates are inconsistent because they are aggregated from observed variables and include measurement errors. This bias tends to manifest itself in slightly higher estimates for factor loadings and lower path coefficient estimates.

In response, researchers working with PLS-SEM argue that it has been shown that its estimates will approach true parameter values when they increase the number of indicators per construct and sample size (VINZI *et al*., 2010). For those who compare PLS-SEM and CB-SEM, it has been shown that the mathematical differences between the estimates are irrelevant, with PLS-SEM being as good a choice as CB-SEM to treat reflective models and superior to the latter, to treat formative models (SARSTEDT *et al*., 2016).

6 APPLIED EXAMPLE

To exemplify the application of this statistical technique to a database, we chose to use the SmartPLS software. It is intuitive, simple to use, and has free licenses for students[2]. Books, articles, and videos support users and offer technical clarifications about it. Our example used the fourth version of SmartPLS, released in August 2022.

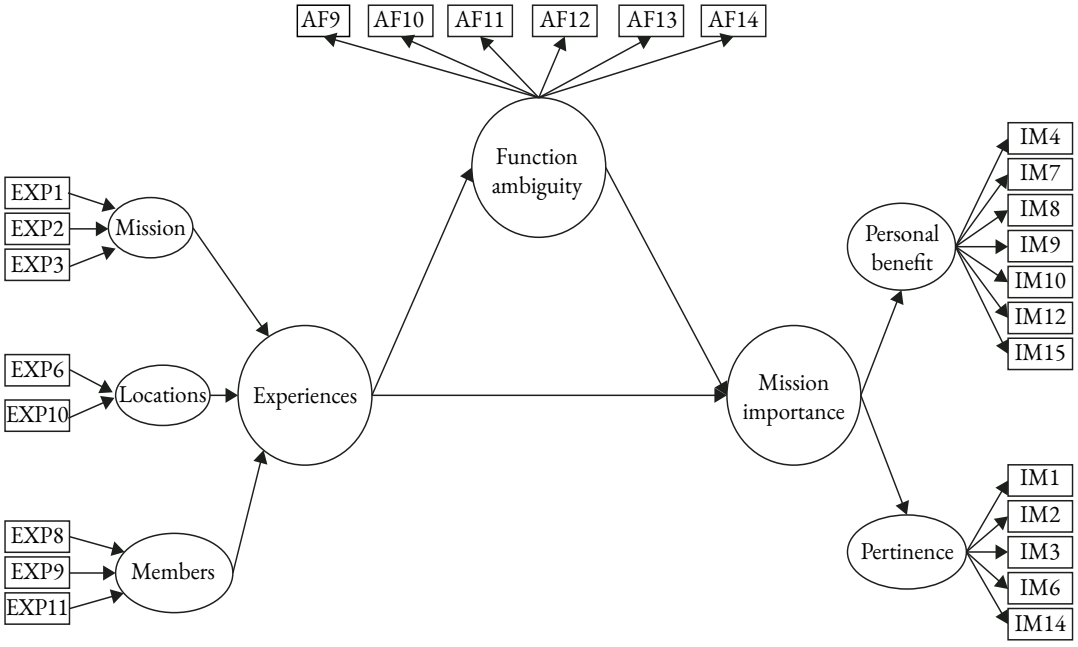
We tested a hypothetical model in which the experiences of military personnel on the ground predict their evaluation of the importance of a mission, which may or may not be mediated by function ambiguity. This model was theoretically conceived from evidence that borders the theme, gathered by a systematic review of the literature — a greater discussion about the

2 https://www.smartpls.com/

theoretical bases of this model used for example lies outside the scope of this study but can be found in Neves (2022).

A formative model operationalizes the first exogenous variable, ground experience. A reflective model operationalized the second exogenous variable and the endogenous variable. Both ground experience and the importance of a mission constitute second-order latent variables, i.e., composed of other latent variables (mission, locations, and members; personnel, and pertinence, respectively). A metric study previously analyzed all these measures, pointing out which observable variables should be retained for each latent variable in a sample similar to our database (NEVES, 2022). We find a direct prediction between ground experience and the importance of a mission and a prediction that function ambiguity may mediate this. Ellipses represent latent variables; rectangles, observable variables; and arrows, prediction paths (Figure 2).

Figure 2 — Hypothetical theoretical model for the applied example



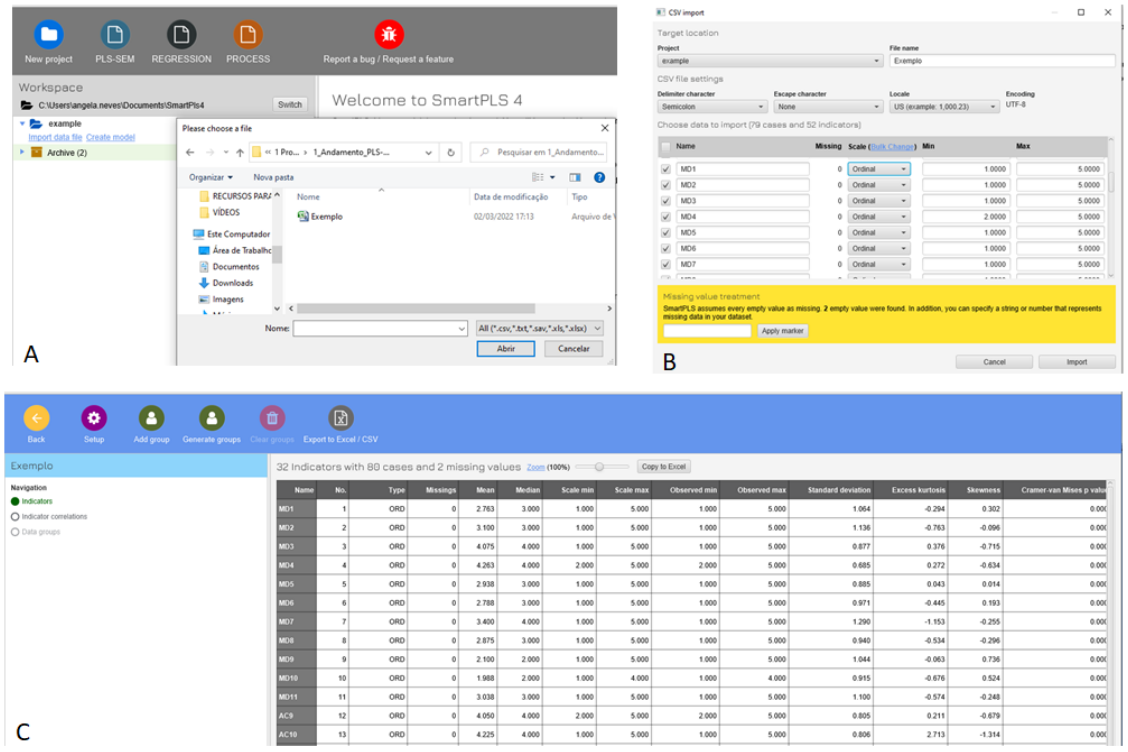
Source: Elaborated by the authors, 2022.

We estimated the minimum sample size to test this model on G*Power, according to Bido *et al* (2014). Thus, two exogenous variables (ground experience and function ambiguity) predict the endogenous variable (importance of a mission), and considering a 0.15 effect size, 80% power, and a 0.05 alpha, the suggested minimum sample size is 68 participants, the ideal being triple this value. This example has a database with 80 participants.

Researchers may organize their data in a spreadsheet in their preferred software, which they must save in the *.*csv format. Its first row should contain the labels (names) of the evaluated variables.

After starting the program, choose "new project" and name it according to your research. Next, a project folder will open in the left menu with two options: "import data" and "create model" (Figure 3A). Start with the first option and choose the *.*csv worksheet with the research data. Once the data are imported, SmartPLS opens a new window for researchers to adjust their data measurement and report any code for missing data (Figure 3B). Click "import" and the datasheet will be loaded with the option to identify sample groups, if relevant (Figure 3C). Once imported correctly, the data will be identified in the project folder in green.

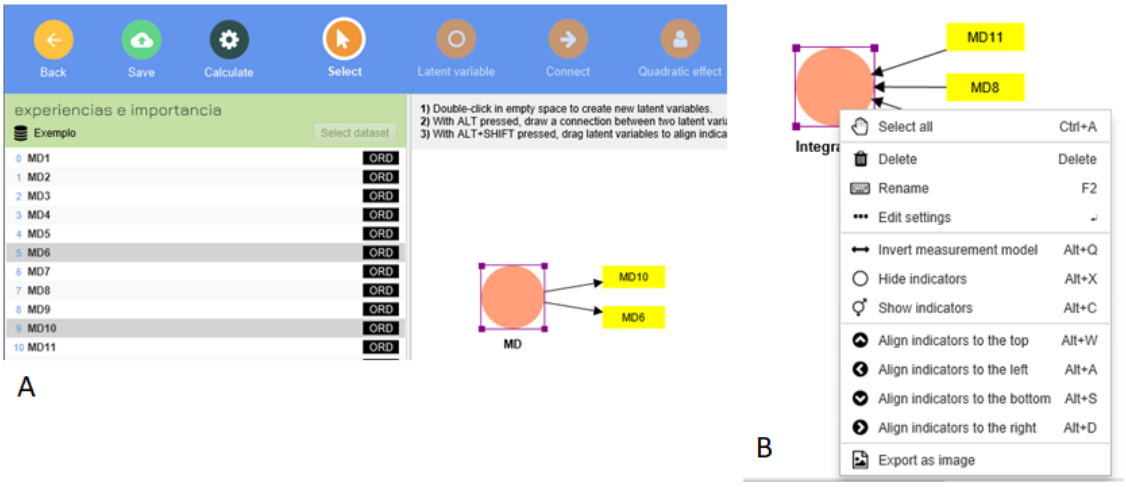
Figure 3 — Importing the database into the software



Source: Elaborated by the authors, 2022.

Now choose the second option, "create model." A window will open for the template to be named and the template type to be chosen. To analyze structural equations, choose "PLS-SEM." Click "Save." The menu on the left will identify the observable variables and model indicators. Select all that reflect or form the same latent variable (in our example, we selected items MD1, MD2, MD3 for the latent variable Mission) and drag them to the right (graphic window), already positioning it according to your hypothetical model. A text window will open to correctly name the latent variable. Press "enter" (Figure 4A). The left mouse button can open a menu to adjust the latent variable, including model type (whether formative or reflective), observable variable positioning, among other options (Figure 4B).

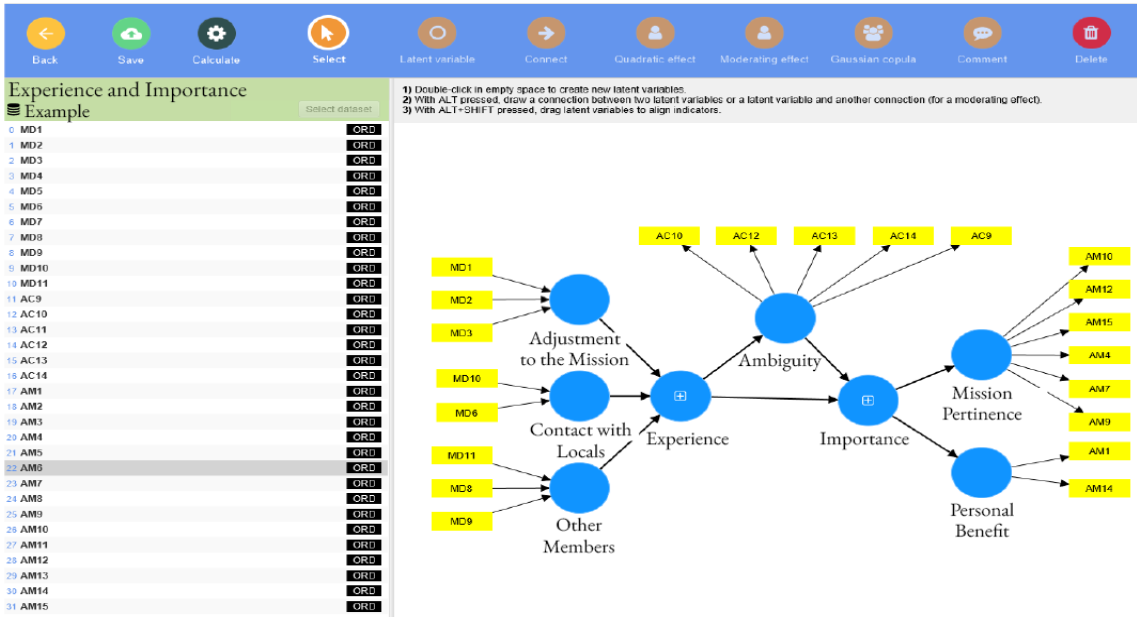
Figure 4 — Initial steps to configure measurement and structural models



Source: Elaborated by the authors, 2022.

To configure second-order latent variables, select all the observable variables that form/reflect first-order latent variables. Name and choose "hide indicators" to avoid polluting your model. Repeat this operation until you properly characterize all first- and second-order latent variables. Then, click the top menu under "connect" and determine the prediction paths between variables (Figure 5). Once these initial phases are complete, the model is ready to be analyzed.

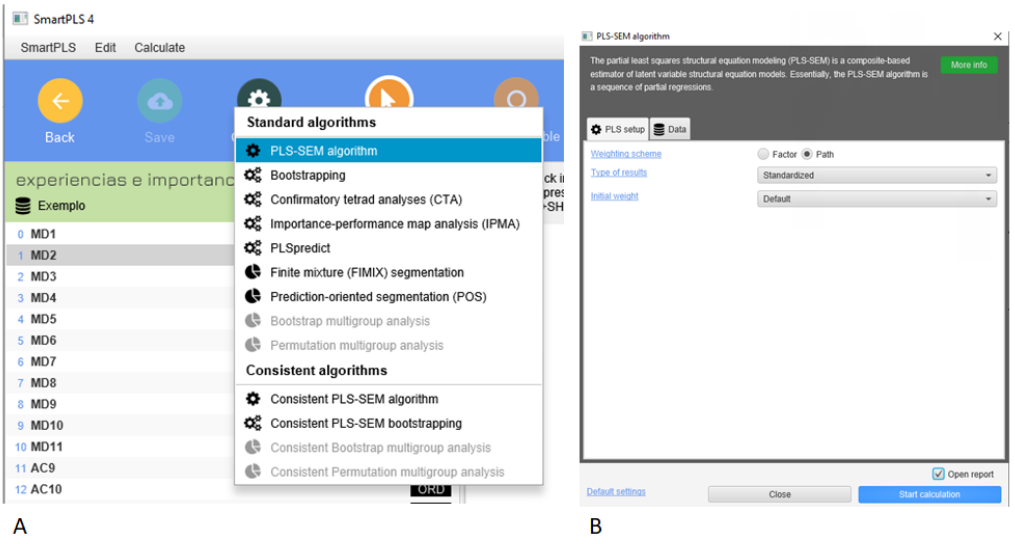
Figure 5 — Model ready for analysis



Source: Elaborated by the authors, 2022.

Our example has reflective and formative measurement models, and we chose the first option (Figure 6A). In the analysis configuration window, make sure to select "Path" for "Weighting Scheme" (Figure 6B).

Figure 6 — Starting the analysis



Source: Elaborated by the authors, 2022.

A new window will open with the analysis output and the menu on the left will make analysis results available. Above the graphical window, you will find options for which results to visualize in the measurement (outer) and structural models (inner model) and regarding latent variables. This analysis generates information of researchers' interest in the output "quality criteria."

We initiated our analysis by the measurement model, as per the literature. In our example, we modeled the first-order domains on the experience scale as formative (contact with locations, adjustment to missions, and other personnel). We inspected its variability indicators and factor weights at this stage. We found that all indicators had adequate VIF values. The observable variable EXP6 had a non-significant factorial weight ($p = 0.057$) but a high factor loading ($\lambda = 0.59$). We decided to keep it in the model, assuming its importance to be absolute and non-relative (Table 2). Results indicated no correlation between indicators (which is highly desirable) and that all the indicators significantly contributed to form the construct of experience with peace missions.

Function ambiguity, mission pertinence, and personal benefit constitute the first-order latent variables in the analyzed example, which we modeled as reflective constructs. We observed that the observable variable AF11 of the latent variable Function Ambiguity ($\lambda = 0.44$); MI8, of the latent variable Personnel ($\lambda = 0.46$); and MI 2 ($\lambda = 0.25$), IM3 ($\lambda = 0.11$), and IM6 ($\lambda = 0.13$) of the latent variable Pertinence had low factor loadings. Thus, we removed them from our model. Researchers must remove each observable variable

individually, performing a new estimation for each removed element. Researchers who remove observable variables from a first-order latent variable must also remove them from second-order latent variables. To remove a variable from the template, select "delete" from the top menu.

After removing those observable variables, we generated satisfactory evidence of convergent validity (AVE) and internal reliability (construct reliability). These results enable us to claim that the observable variables in each first-order latent variable adequately reflect them, that the measurement these scales made in the sample is free of random errors, and that we can consider these results as reliable (Table 2).

Table 2 — Quality indicators of measurement models for latent variables and first-order indicators

	λ/ω*	VIF	CC	AVE
Function ambiguity	0.51 – 0.83	n/a	0.84	0.52
Personal/career benefit (IMP)	0.55 – 0.86	n/a	0.73	0.57
Mission pertinence (IMP)	0.49 – 0.97	n/a	0.89	0.59
Locations (EXP)	*0.40 – 0.83	1.23 – 1.39	n/a	n/a
Mission Adjustment (EXP)	*0.36 – 0.57	1.06 – 1.61	n/a	n/a
Other peacekeepers (EXP)	*0.46 – 0.51	1.20 – 1.43	n/a	n/a

Note: IMP = importance of the mission; EXP = Experiences with peace missions; λ = factor loading; ω = factorial weight; VIF = multicollinearity indicator; CC = composite reliability; CVA = average variance extracted; n/a = not applicable. Values marked with * refer to ω.

Source: Elaborated by the authors, 2022.

Then, we only inspected evidence of discriminant validity for variables we modeled as reflexive. The analyzed data showed satisfactory evidence (Table 3), i.e., in this sample, the first-order latent variables in the model really differ from each other.

Table 3 — HTMT test values for first-order latent variables

	1	2	3
1) Function ambiguity	-		
2) Personal/career benefit (IMP)	0.77	-	
3) Mission pertinence (IMP)	0.72	0.30	-

Note: IMP = importance of the mission

Source: Elaborated by the authors, 2022.

It is also interesting to bring cross-loading analysis as evidence of discriminant validity (Figure 7), identifying the items in each predicted latent variable.

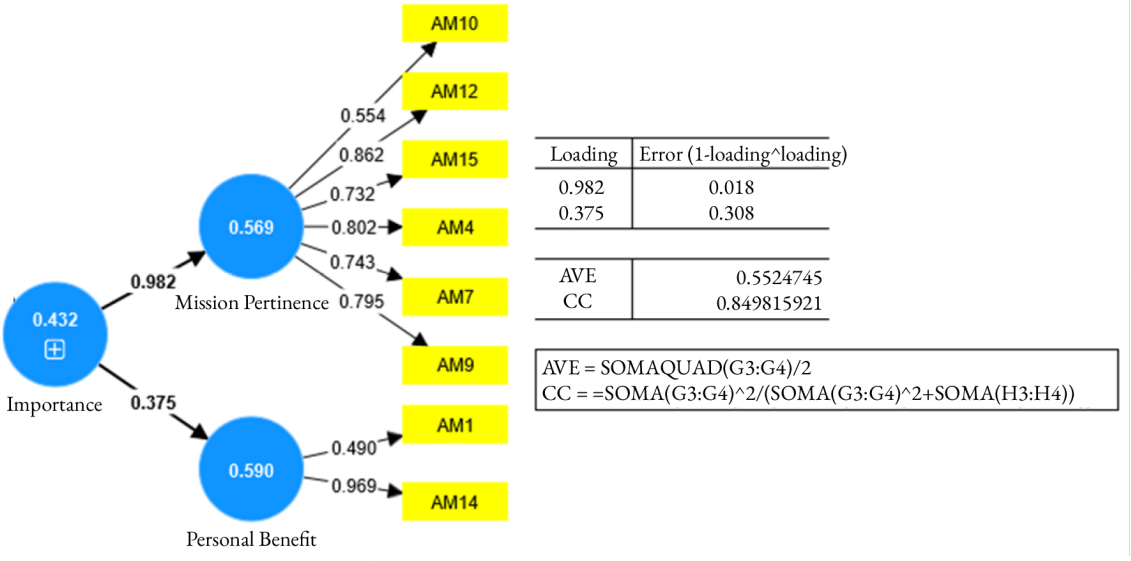
Figure 7 — Table with cross-factor loadings

	Ambiguity	Personal Benefit	Mission pertinence
AF10	0.734	-0548	-0.328
AF12	0.734	-0.316	-0.389
AF13	0.932	-0.391	-0.472
AF14	0.768	-0.264	-0.791
AF9	0.510	-0.371	-0109
IM1	-0.120	0.490	0.017
IM10	-0.551	0.199	0.554
IM12	-0.619	0.199	0.862
IM14	-0.512	0.969	0.213
IM15	-0.473	0.160	0.732
IM4	-0.484	0.167	0.802
IM7	-0.456	0.151	0.743
IM9	-0.401	0.026	0.795

Source: Elaborated by the authors, 2022.

The model has importance of the mission as a second-order latent variable measured as a formative model and a second-order domain, ground experience. We estimated the AVE (i.e., composite reliability) for the former. These calculations must be done by hand (or in an Excel table) as the software will do the calculations with observed repeated variables, rather than with first-order latent variable loadings (Figure 8).

Figure 8 — AVE and Composite Reliability calculation in the second-order latent variable



Source: Elaborated by the authors, 2022.

We avoided performing the HTHM test due to the absence of another latent variable measured as a reflective model from which it could differ. The presence of any such variable would require the test. For the ground experience domain, we observed multicollinearity between first-order domains (Table 4).

Table 4 — Quality indicators of latent variables and second-order domain

	VIF	CC	AVE
1) Importance of the mission	n/a	0.85	0.55
2) Ground experiences	1.32 – 1.36	n/a	n/a

Note: VIF = multicollinearity indicator; CC = composite reliability; Average variance extracted = mean variance extracted; n/a = not applicable

Source: Elaborated by the authors, 2022.

We found all values to be satisfactory, indicating that our adequate first-order variables (convergent validity) properly reflected second-order variables and generated reliable data (internal reliability) and that the formative construct had no unwanted correlations (multicollinearity). As these values were satisfactory, we analyzed structural models, testing the hypotheses of this study.

It is important to test collinearity before evaluating structural models. For this, we analyzed variance inflation factor (VIF) values for each latent variable in the structural model since the beginning of analysis. All values lie within those in Hair *et al*. (2017), i.e., below 5 (Table 5)

We used bootstrapping to investigate the significance of the indicators. It can be accessed in the top menu under "calculate." In the "PLS setup" tab, make sure to select "path" in "weighting scheme." Moreover, default settings can generally be maintained. The use of bootstrapping to analyze the significance of factorial loads obtained for observable variables is not only based on one estimation of the model, but also calculates estimates of parameters and their confidence intervals based on multiple estimates (HAIR *et al*., 2017; HAIR *et al*., 2017). The information of interest is in the "final results" topic of the bootstrapping analysis output.

Table 5 — Direct, specific indirect, and total effects

Effect	Structural Recovery	VIF	β	*t*	p
Direct	Function ambiguity → Importance of the mission	0.00	−0.74	8.41	<0.001
Direct	Ground experience → Function ambiguity	1.00	0.26	1.96	0.05
Direct	Ground experience → Importance of the mission	0.00	-0.10	0.94	0.35
Indirect	Ground experience → Function ambiguity → Importance of the mission	n/a	0.20	1.91	0.06
Total	Ground experience → Importance of the mission	n/a	0.11	0.72	0.47

Source: Elaborated by the authors, 2022.

The Student's t-test analyzes the hypothesis that correlation coefficients equal zero. Results above 1.96 reject hypotheses and show a significant correlation (HAIR *et al.*, 2017). Researchers should avoid considering values attributed to first-order latent variables. In the output, the results of interest are in the "final results" topic. Table 5 shows coefficient values between constructs and their Student's t-test.

We only observed a direct and statistically significant effect of function ambiguity on mission importance ($\beta = -0.74$; $p < 0.001$). This indicates that role ambiguity negatively predicts the perception of mission importance.

We observed the coefficient of determination (R^2) to evaluate the extent to which the model explained dependent variables. It was based on the analyses in Cohen (1988), which determines that values equal to 2%, 13%, and 25% are considered small, medium, and large, respectively. Analyses showed that function ambiguity (predicted by ground experience) obtained an $R^2 = 0.06$ (considered small) and that importance of the mission, an $R^2 = 0.51$ (considered large). This enables us to infer that the prediction model explains 51% of the importance given to the mission by military personnel (both regarding their perception of its value to their career and the mission itself). However, the explanation of function ambiguity by ground experience is very poor (about 6%), indicating to the researcher that other factors should be considered in a future model to explain the manifestation of this variable more comprehensively.

In addition to evaluating the magnitude of R^2 values as a criterion of predictive accuracy, it is necessary to evaluate the variable effect size (i.e., their explanatory importance in the model) by the Cohen indicator (f^2). This indicator evaluates whether the construct, when omitted, importantly impacts other endogenous constructs. F^2 values equal to 0.02, 0.15, and 0.35 are considered small, medium, and large effects, respectively (Cohen, 1988), of an exogenous latent variable. Results indicated that the relation Function ambiguity →Mission importance has a large effect size ($f^2 = 0.98$) and that Ground experience →Mission importance has a small effect size ($f^2 = 0.02$), as does Ground experience →Function ambiguity ($f^2 = 0.08$), understandable given the non-significance of these last two predictive relations. Function ambiguity constitutes an important exogenous variable for the model. R^2 and f^2 results can be accessed after the PLS-algorithm analysis request in the "quality criteria" topic of the analysis output.

The Stone Geisser indicator (Q^2) indicates the predictive relevance of a model. It evaluates the contribution of an exogenous construct to the Q^2 of an endogenous latent variable. It can be calculated by "blindfolding" or "PLS-predict," which is based on a series of interactions. SmartPLS4 performs only the latter (the third version of the software still does both). It can be chosen from the top menu under "calculate." In the output, the results of interest are in the "final results" topic (LV prediction sumary). Specifically, when a PLS-SEM model has predictive relevance, it accurately predicts the endogenous variables of the model. Values equal to or greater than zero indicate model accuracy (Table 6).

Table 6 — Stone-Geisser Indicator values for the endogenous variables of the model

Endogenous variables	MAE	Q^2_predict
Function ambiguity	0.82	0.04
Importance of the mission	0.83	0.00

Note: MAE = mean absolute error; Q^2 = Stone Geisser indicator.

Source: Elaborated by the authors, 2022.

This example of PLS-SEM estimation process only brought its main analyses to evaluate measurement and structural models[3]. We kept the database small and made a simple model so researchers who is still a novice at this statistical technique can use it under the free license of the software.

7 CONCLUSION

We sought to describe a multivariate statistical technique that can help military science researchers to propose new theories based on quantitative data. We hope this theoretical-methodological essay instigates other researchers to consider this exploratory approach to explain military science, international security, and defense phenomena. A robust approach to the attitudes determining individuals' behavior toward security perception, threat, power projection, and economic investments can benefit not only the understanding of our local reality but also the complexities of these phenomena.

3 The database can be requested from the first author of the article by e-mail.

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The Grand Strategy: changes in ways and means due to Information Operations and the threat to the interests of Brazil and Argentina

La Gran Estrategia: cambios de formas y medios por las Operaciones de Información y la amenaza a los intereses de Brasil y Argentina

Abstract: The objective of this work is the analysis of the Grand Strategy of the States by the capacity of Information Operations. Initially, the analysis focuses on the traditional role of ways, means, and ends with military power in the constant interaction between States, the threat to its existence. In a second moment, the changes in the ways and means of transnational threats and the global commons will be detailed, under the effect of globalized technology and concepts vulnerable to the gray zone and the narrative. In a third point of analysis are the ways and means of the grand strategy of the main world states in multidomain and influence, which implies an extensive use of Information Operations in a great competition. Finally, the conclusions point out that the maintenance of the national interests of countries such as Brazil and Argentina require the adaptation of multi-domain military strategic doctrine with extensive use of Information Operations as the basis of its grand strategy.

Keywords: grand strategy; information operations; global commons; multidomain; transnational threats.

Resumen: El objetivo de este trabajo es el análisis de la Gran Estrategia de los Estados por la capacidad de Operaciones de Información. Inicialmente, el análisis se centra en el papel tradicional de los modos, medios y fines con el poder militar en la interacción constante entre los Estados, la amenaza a la existencia del mismo. En un segundo momento, se detallarán los cambios en los modos y medios de las amenazas transnacionales y los *global commons*, bajo el efecto de la tecnología globalizada y conceptos vulnerables a la zona gris y la narrativa. En un tercer punto de análisis se encuentran los modos y medios de la gran estrategia de los principales estados mundiales en multidominio e influencia, que implica un uso extensivo de las Operaciones de Información en una gran competencia. Finalmente, las conclusiones apuntan que el mantenimiento de los intereses nacionales de países como Brasil y Argentina requiere la adecuación doctrinaria estratégica militar multidominio con amplio uso de las Operaciones de Información como base de su gran estrategia.

Palabras Clave: gran estrategia; operaciones de información; global communs; multidominio; amenazas transnacionales.

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1 INTRODUCTION

National security issues may not have a worldwide consensus of the anarchic organization of states, but the threats exist. The grand strategy of states links explicit values to ends, ways, and means. However, the solutions are not clear, and the Information Operations capability is presented as part of a military grand strategy to deal with the new phenomena of realistic multidomain warfare. Brazil and Argentina are geopolitically the largest countries in South America, but this does not represent a defense potential, as the technological advancement of information capabilities challenges defense capabilities in relation to the interests of world powers.

The contemporary study of grand strategy includes debates about its definition. The grand strategy can be understood as part of foreign policy, while others believe that it covers foreign policy, military doctrine, and tactics. The conventional assumption is that grand strategy links explicit values of ways and means. However, there is a lack of consensus on the meaning, as it allows to incorporate economic and institutional dimensions into the ends or to extend the analysis to non-traditional threats, such as climate change, pandemics, and economic security (BALZACQ; DOMBROWSKI; REICH, 2019).

In general, the analysis of a country's traditional grand strategy is twofold in ways, the first being a national and global security approach, focused exclusively on military force, relationships, and threats. In a second view, it has a conception of strategy that distinguishes between foreign and defense policy, and does not fully cover diplomatic, economic, social, and cultural issues (MILANI; NERY, 2019).

However, the realistic organization of the armed forces, directed at state threats and ends, is constantly threatened by the changing course of transnational events. The essence of traditional military power is challenged by new actors who merged the media with the population and transcended state borders. Technological advances and new domains of warfare created an information fog in the face of state actors such as the United States, United Kingdom, Russia, and China with new strategic multidomain tools and non-state actors with new information threat techniques.

The strategic scenario of Brazil and Argentina, regional geopolitical actors in the South Atlantic continent, shows that the ways of threat are more complex than the previous ones, as they will have to face threats of a subtle, multipolar, and undefined nature in terms of information and influence. Threats can be both state and transnational, physical or not, as a phenomenon with gaps and common interests. In this scenario, world powers have updated their defense policies by other means and included concepts related to the military power of information. The military power of regional states is challenged to actualize the multidomain force competition interaction between states. So how is the traditional grand strategy of ends affected by the changing ways and means of multidomain information?

The following will analyze how traditional state interests may be challenged by the universe of multidomain military competition in a grand strategy of Information Operations that may affect the interests of Brazil and Argentina.

2 THE REALISTIC DEFENSE AND THE ENDS OF MILITARY POWER

The philosophical origin of the geopolitical military power of a state lies in its own realist identity of ends. "State is a human community which, within a given territory (the 'territory' is a distinctive element), claims (successfully) for itself the monopoly of legitimate physical violence" (WEBER, 1967, p. 83; our translation). Realist theories of international relations underlie the existence of states and the permanent game of competition for space and power.

From a geopolitical realist perspective, the projection of power factors (military, economic, political, psychosocial) is conceived so that all interaction between actors in the world geopolitical system is subject to a game of power interests, and that their action tends at least to maintain or improve their relative position on the world board to the expense of other actors.

According to Hobbes, the essence of the State consists of: "an entity whose acts unite a large crowd, by mutual covenants, made among themselves, is instituted by each as the author, for the purpose of using the strength and means of all, as it may judge proper, to secure the common peace and defense" (2005, p. 141; our translation).

For the geopolitical realism of the ends, the referent object of security will be the territorial integrity of the State, since it is the State that can, on the basis of its position in the system, preserve the interests of the nation and with them the welfare of society. The central objective of a State's security policy must be to have all the indispensable means and resources necessary to preserve the interests of the nation, in order to maintain the integrity of the State's priority interests and to free them from threats (MØLLER, 1996).

Each State organizes in ways its coercive power to guarantee the internal order of its institutions and to maintain its *status quo* in relation to the influence of other States, its defense. In the rationalist approach, States are the actors who hold power and seek means to realize their material and concrete interests in the face of an anarchic international environment, with the power aspects aimed at guaranteeing their *status quo ante bellum* (MORGENTHAU, 2003). Thus, the defense of the State has always been related to the existence of a military power that sustains it.

The construction of the political order of states, internal or external, can be known by the characteristics of some authors who defined it, such as Hobbes in the absolute state, Locke with parliamentary monarchy, Montesquieu with the limited state, Rousseau with democracy, Hegel with constitutional monarchy (BOBBIO, 1996). In all situations the state has its essence in the constitution of military power, even in democracy, "in the general sense of power and the possibility of imposing one's own will on the behavior of others, domination can take the most diverse forms" (WEBER, 1964, p. 696). This is because the State's interest predominates, in terms of its survival as a sovereign State.

In the context of sovereignty, the ways of the formation of the absolute State are achieved through a double process of concentration and centralization of power over a given territory. Concentration means the power to make laws, jurisdictional power, the power to use internal and external force, and the power to impose taxes. Centralization refers to the process of elimination or disallowance of lower legal systems, such as cities, corporations, private companies, which survive due to the tolerance of the central power (BOBBIO, 1996).

However, the nature of the state is to survive in a competitive world and sovereign power can be threatened by other means on the multidominant scale of military power. The use of power, with ways and means to guarantee sovereignty or interfere with that of other states, can be classified by the definition of geopolitician Bernard Cohen (2015): great power, first order states with the capabilities and ambitions to expand their influence beyond the regions in which they are situated (United States, Russia, China, Germany, and Japan); regional power, second order states in competition and their geopolitical reach is regionally confined (France, United Kingdom, India, Brazil, Iran, Turkey, and Australia); third order states, they have only a single type of capability to influence their neighbors (Ukraine, North Korea, Colombia, Chile, and Argentina); the other states are in fourth or fifth order.

Because of the essence of states and the nature of international relations driven by ends, conflicts of state interests will continue to trouble the international scene. The realist view is that any attempt to guarantee a system of collective security in the world, with the annulment of military power, is destined to fail because of the impossibility of freezing the *status quo* in a competitive international system between states (MORGENTHAU, 2003). From a realist perspective, the projection of power factors will be increasingly characterized by a multidomain performance of military power. The projection of power factors (military, economic, political, psychosocial) is seen in its integrity, but mainly realistic. Any interaction between the actors of the global geopolitical system is subject to a game of interests of the powers because it is understood as the power to dictate laws, the jurisdictional power, the power to use force inside and outside.

Given the above, the realist school of defense remains important in the current strategic context of Brazil and Argentina and the military power of the States that considered great power as the axis of action of international actors. However, can the realist vision, sovereign boundaries, people's security, and military aspects keep up with the changing ways and means of information and transnational multidomain scenarios?

3 THE TRANSNATIONALIZATION OF THE WAYS AND MEANS OF THREATS

Since September 11, 2001, the geopolitical status of threats to states is uncertain. New phenomena such as globalization and the transnationalization of the means are threatening the boundaries beyond absolute states. As for the ways, the traditional strategy needs to be replaced by a grand strategy that demands the participation of different actors in different areas of the power structure in the formulation of these state policies. According to Buzan (1991), threats are not only military, but also political, economic, environmental, and social, which may determine a holistic approach to threats, beyond the traditional concept of military defense of the State.

According to Nina Silove (2018), there is a general tendency to use the term grand strategy inconsistently. She identifies three uses of grand strategy which she calls grand plans (a deliberate and intentional plan of action), grand principles (conceptual coordinates), and grand behaviors (an established pattern of behavior or practice). Silove's formulation is significant to the purpose of the ways in highlighting the relationship between the articulated ends of a state,

its strategic planning and its behavior in attempting to implement the grand strategy. Thus, the change in transnational social behavior caused by information via means may affect the traditional form of grand strategy.

Liang and Xiangsui (1999, p. 130) already said that there is a war by other means combined with threats beyond state boundaries, which will assemble and mix with each other more means to solve a problem in a wider range than the problem itself. For realists, when national security is threatened, the response is not simply a matter of selecting military means. However, today, considering the issues of information warfare, the meaning of the word "country" in terms of nationality or geography is no more than a small or large link in human society.

> Countries are increasingly affected by regional or global organizations, such as the European Union, ASEAN, OPEC [...] and the largest of all, the United Nations. In addition to these, a large number of multinational organizations and non-state organizations of all shapes and sizes, such as multinational corporations, trade associations, peace and environmental organizations, the Olympic Committee, religious organizations, terrorist organizations, small hacker groups, etc., are present in the countries. These multinational, non-state and supranational organizations form a global power system that is emerging. (LIANG; XIANGSUI, 1999, p. 130; our translation)

The crises that will arise in future scenarios will be more complex than previous ones, as threats will have to be confronted by other ways and means of a subtle, multipolar, and undefined nature, without the need to categorize a nation's state of war or peace (VERGARA; TRAMA, 2017). This phenomenon of conflict that is neither war nor peace was defined as a gray zone where it is not easy to distinguish between who, what or how states relate to each other. The distinction between security and defense has become blurred. As Cha points out "globalization creates an interpenetration of international and domestic affairs [...] this 'intermestic' approach to security policy is related to the transnationalization of threats" (2000, p. 397; our translation). In this scenario, state interests are relativized by the narrative, and there is a constant invisible competition for space and power.

Examples of ways and means of transnational threat include competition for spaces outside a national jurisdiction, known as global commons (SANDLER, 1992). The possibility of a global consensus of global powers on common spaces is questioned by the authors. Brzezinski (2012) explains that the United States will have difficulty leading the protection and good faith management of the global commons, such as climate change, because it does not have the necessary power in the face of the geopolitical interests of Russia and China. In information warfare, the analysis of geopolitical resources transcends the geographic space under the dominion of States, extending the study to common areas, or without defined spatial domain, and the means of military action cover a multidomain nature.

The management of the global commons: sea, space, water security, and the environment, is a current issue, which proposes an international agenda related to the ends. Antarctica

is an example of common spaces, which contain transnational interests. Seven countries made sovereignty claims since the Antarctic Treaty of 1959: United Kingdom – Australia – New Zealand – France – Norway – Argentina – Chile. However, Antarctica technically belongs to no one and, according to the Defense Strategy (AUSTRALIA, 2020), the environment may include conflicts between states and the conduct of covert military activities in the gray zone of conflict. The threats challenge the Antarctic Treaty by the struggle for sovereignty, the non-militarization of Antarctica, and the commitment to keep the Protocol on Environmental Protection (1991) that provides protection of the environment and prohibits mining and oil extraction.

Meanwhile, by the means of information warfare, the ways of threats can come from the understanding that large areas with natural resources are catalogued as global common for the environmental just cause of mankind. This would be the case of the Amazon between Brazil, Venezuela, Colombia, Ecuador, Peru, and Bolivia; or the Argentinean and/or Chilean Patagonia, with a partial British presence (BORRELL, 2020). South America includes a great variety of biogeographic regions threatened by the interests of other states, its main resources being: energy, fresh water, food and the epicontinental sea. The continent has the largest extension of jungles and rainforests in the world, richest in biodiversity (KOUTOUDJIAN; CURTI, 2015). In a context of common regional threat, Paraguay, Argentina, Brazil, and Uruguay have the largest water reserve, the Guarani Aquifer, beyond the common interests in the South Atlantic continental shelf (KOUTOUDJIAN; CURTI, 2015).

According to Van Creveld (2007), another important group of transnational threats by other ways and means are terrorists, guerrillas, and thieves, a situation that benefits from the difficulty of reaching a consensus on the definition of national security and defense, but which are built on charismatic rather than institutional bases and motivated by fanaticism or ideologies. As low-intensity conflicts grow in the future, intermingling with the possibility of traditional state conflicts, they will produce a collapse in Clausewitz's triune structure of defense: government, people, and army. The difference between front and back of the state, as civilians and military, will disappear under transversal and information threats. The United Nations Development Program, in its 1994 report, "is based on addressing threats from both military and non-military sources, such as interstate conflicts, human rights violations, terrorism, organized crime, drug trafficking" (OROZCO, 2006, p. 176; our translation).

Another common area of competition is cyberspace, which represents a great opportunity to define other ways and means in the strategy. "Cyber incidents and attacks are now a source of threat in the globalized world, due to their ability to access diplomatic, governmental and military information systems" (VERGARA; TRAMA, 2017, p. 14; our translation). There is a war of narrative and influence. The attacks are continuous and permanent, without methods, scope, and consequences (VERGARA; TRAMA, 2017). "Cyberattacks present a new and growing threat, which international law and most current national laws are unable to cope with" (VERGARA; TRAMA, 2017, p. 88; our translation). The interconnected domain environment expanded the possibilities in space and time of information threats, determining the fusion of the multidomain jurisdictional fusion of state interests. Attacks do not respect the

limits of the land, air, and maritime domains of military conflicts, expanding the possibilities of relativization of borders, actors or interests that take advantage of the cyber domain.

In a great competition of ways and means, states and non-state actors are rapidly expanding their investment in cyberspace. Threats operate among populations with whom they often share a cultural or ethnic identity, making it difficult to distinguish between threat and non-threat. The information environment increased in multidomain complexity of military employment and the control of will and influence can affect decision makers. Because of the widespread availability of technology, the information environment became an even more important consideration for military planning, because armed forces depend on these technologies (ESTADOS UNIDOS, 2016). Military technology yields to expanding possibilities of artificial intelligence and unmanned weapons are increasingly used. The control of influence and the power of information became part of the strategic considerations of the most recent global commons and transnational threats of the 21st century, following the restructuring and recovery of power between Western and Eastern states, with the expansion of the role of China and Russia on the international chessboard of military competition.

Therefore, in information warfare, the threats will be not only from great powers and regional adversaries, but also from extremists, violent and criminal non-state actors, and from threats such as climate change, infectious diseases, cyber-attacks, and disinformation that do not respect national borders (ESTADOS UNIDOS, 2021). The transnational character of threats' ways and means requires the expansion of the concept of traditional use of military power, evolving towards a concept of a multidomain weapon that should imply a grand strategy. So, what would be the best strategy for state security?

4 THE GRAND STRATEGY AND THE CHANGE OF WAYS AND MEANS THROUGH INFORMATION OPERATIONS

The realistic identity ends of the states considered world leaders lead the countries to a permanent competition for common interests. In the realist vision, military means and ways are no longer sufficient. The idea of a grand strategy requires the participation of different actors in the formulation of state policies, incorporating the phenomenon of information into the pluralism of actors.

The information strategy experiences the integration of other means of Cyber Warfare capability with Intelligence, Information Operations, Cyberspace, Electronic Warfare, and Space Operations as part of a Multidomain Task Force as Strategy concept (THE INTERNATIONAL INSTITUTE FOR STRATEGIC STUDIES, 2021). To exercise its internal sovereignty, or even to maintain its *status quo* in the face of non-state threats, each country uses the Grand Information Operations Strategy in different ways and goes beyond state military boundaries. In the grand strategy, the ways used are comprehensive, encompassing a diverse range of instruments of national power rather than focusing on a single type of instrument (LAYTON, 2012).

Brazil and Argentina made little progress in understanding the scope of the multidomain grand strategy of information and the change of ways and means. In the context of global competition, peripheral countries may be under the constant influence of great power

interests. At present and in the future, the global commons and the relativization of the possession of territories, such as the Amazon Rainforest and areas of the South Atlantic and Antarctica, are in dispute. The multidomain conflict establishes a challenge of influence and interests, involving the application of military instruments in a holistic and integrated manner.

The cyber environment is the common space of competition and the most active in the multidomain, it has no borders and is a transnational threat, making states think about defense structures. However, it is not the only military instrument of information warfare. The Western approach, such as Brazil's or Argentina's, to cyber defense typically focused on ways and means with technical responses, without considering the interface with information warfare. "This approach is entirely suitable for some persistent or background threats, but is not always sufficient for a broader, more holistic approach such as that taken by Russia" (GILES, 2016, p. 22; our translation).

As an example, for the US, successful military contributions in the multidomain require sustained integration in ways and means of conventional, irregular, and special operations capabilities (ESTADOS UNIDOS, 2020c). The Russian Federation (RF) and the People's Republic of China (PRC) use all the instruments of their national power to undermine and remake the international system to serve their own interests (ESTADOS UNIDOS, 2020a). United Kingdom is militarily employing Information Operations in integral defense, increasing the escalation of competition, and the rise of crisis and conflict (REINO UNIDO, 2021).

According to the US Strategy there is irregular warfare by other ways, between state and non-state actors to influence populations and affect legitimacy. The traditional grand strategy incorporated the importance of the participation of actors additional to the military. This type of warfare favors other means, indirect and asymmetric approaches, although it can employ the full range of military and other capabilities in order to erode an adversary's power, influence and will. Information Operations, unconventional warfare, stabilization, foreign internal defense, counterterrorism, and counterinsurgency are also included. The means of related activities, such as psychological operations, cyberspace operations, combating threat networks, threat financing, civil-military operations, and security cooperation also shape the information environment and other areas of competition and conflict centered on the population (ESTADOS UNIDOS, 2020c).

According to US strategic scenarios, the world's powers are competing on artificial intelligence and quantum computing, which could shape everything from the economic and military balance between states to the future of work, wealth and inequality within them. Next generation (5G) telecommunications infrastructure will set the stage for all aspects of Information Operations. The ways and means of emerging technologies remain largely ungoverned by laws or rules designed to focus rights and values, managing the risk that competition will lead to conflict (ESTADOS UNIDOS, 2021).

Therefore, the Russian concept of ways and means carries computer network operations together with

> psychological operations, strategic communications, intelligence, counterintelligence, maskirovka, disinformation, electronic warfare, weakening of communications,

> degradation of navigation support, psychological pressure, and destruction of enemy computer capabilities. (MSHVIDOBADZE, 2011, our translation)

> Information and psychological warfare will come above all forms and methods of operations in future wars to achieve superiority in troops and arms control and to erode the morale and psychological spirit of the opposing side's armed forces personnel and population. Indeed, information warfare and psychological operations provide a large part of the basis for victory. (CHEKINOV; BOGDANOV, 2015, p. 44; our translation)

Russia conducts information confrontation activities between states and other actors in the information space with "the aim of causing damage to information systems, processes and resources, critical structures, [and] undermining political and social systems in order to destabilize society and the adversary state as a whole" (NOGOVITZIN, 2009, p. 12; our translation). Confrontational information is a broader concept than information operations, encompassing the action of other actors in society, which means a multifaceted, multifactorial struggle involving "social systems, classes, nations [and] states through diplomatic, political, informational, psychological, financial, economic, armed conflict, and many other forms of influence" to achieve strategic and political objectives (SLIPCHENKO, 2013, p. 53; our translation).

China conducts activities in the information gray zone and expands into the Indo-Pacific, Antarctic, and Arctic.

> These activities involve with military and non-military forms of assertiveness and coercion aimed at achieving strategic goals without provoking conflict. In the Indo-Pacific, these activities have ranged from militarisation of the South China Sea to active interference, disinformation campaigns and economic coercion. (AUSTRALIA, 2020, p. 5)

China is widely seen as the closest competitor to the United States in the international artificial intelligence market. China's 2017 Next Generation Artificial Intelligence Development Plan describes as a strategic technology that has become a focus of international competition. Such technologies could be used to counter espionage and assist military targets. In addition, open-source publications indicate that China is developing a set of artificial intelligence tools for cyber operations (ESTADOS UNIDOS, 2020b).

In the United Kingdom the means of Information Operations are in the Integrated Operational Concept of the Ministry of Defense, which emphasizes the need for integration across all combat domains, with different actors, while also incorporating cyber capability under what is called Multidomain Integration. According to the UK strategy, CP 411: "Our armed forces must have the tools and capabilities they need to lead, influence, partner, deter and when necessary to fight to ensure the whole of the UK and its interests are protected" (REINO UNIDO, 2021, p. 11). For Layton (2012), the United Kingdom has a major strategic change in

ways that also involves the development of resources and their allocation, a complex combination that must generate the legitimacy and soft power needed to be successfully implemented from peacetime.

Based on the examples, it can be concluded that the grand strategy means of Information Operations has an expansive and integrative scope of other actors' ways that encompasses the development of a society's economic, demographic, biological, environmental, and social resources. The allocation of these resources and military power are the application of national unified power.

The role of information and information technologies in strategic competition and military operations is evolving considerably, challenging the technological capabilities of countries such as Brazil and Argentina. In the early 2000s, the growth of the Internet occurred, becoming a tool that shapes public opinion and influence politics, economics, and military decision-making. New information technologies will increase the volume of means, accuracy and speed of sharing, processing, and analyzing data. Discussions on advanced information technologies that would have a significant effect on the character of military operations will, in the near future, transform conventional military conflicts into a great information war.

5 CONCLUSION

The analysis presented here allows us to understand how the international strategic scenario is seriously affected by the multidomain capability of Information Operations. The State, as a realistic major player, faces the challenge of developing a major strategy for competition in the information dimension. The development of a grand strategy requires examining how ends, ways, and means actually operate within contrasting contexts. The realist view where national interests are defined in terms of military power on the international stage is no longer sufficient. The idea of a grand strategy requires the participation of different actors in the formulation of State policies, incorporating the phenomenon of information into the pluralism of actors.

The first part of the analysis on the ends allowed us to conclude that the existence of the State still needs to be guaranteed by military power, although adapting it to the possibilities of the ways and means of the future. Inter-state threats remain a very current issue and deserve attention in the military strategy of competition for natural resources and territorial spaces. The realist theory of the existence of the State is fundamental to understand that the referent object of security will be the territorial integrity of the State, since it is the State itself that can, based on its position in the system, preserve the interests of the nation and with them the welfare of society. The institutional process of the State through which the strategy is formulated needs to integrate the ends to a combination of resources (material and social) that can and will be used as instruments in the implementation of a grand strategy.

The second point of conclusion is that there is a change in the ways and means of threats and that these are not only military and between states. There is a great mutation that considers the existence of new actors, interconnected and internationalized threats, being part of a great multidomain information war. However, each country shapes the ways and elements

of material and social resources in very different ways. Threats permeate institutions and require an integral role for the means of national participation. According to the strategic scenarios, the world's powers are competing in the multidomain and transnational threat is the competition for spaces outside national jurisdiction, called global commons. There is great difficulty in defining military boundaries in information warfare, expanding the possibilities of ways and means in disputes in the gray zone of conflicts and involving different non-military sectors.

The third conclusion is that the means of Information Operations are among the main strategies of the States to face the problem, beyond the military operational field. Within the components (ways, means, and ends) of grand strategy, the use of other non-kinetic military ways and means in US, UK, Russian, and Chinese strategy, such as cyber warfare, psychological operations, electronic warfare and communication, are combined with national means to shape grand strategy. In this scenario, the challenge for countries such as Brazil and Argentina is to better understand how information confrontation operates in multidomain warfare, the perspectives for effective international governance of the information domain, and the ways in which information confrontation can be used as an instrument of soft power.

Finally, the ends of realistic interstate threats continued, changes in the ways and means of state and non-state threats are here to stay in the global commons. State borders are no barrier to technology and the transnationalization of information. The military power of Information Operations means can add great defense capability to the State and that is why they are being implemented at the grand strategy level of the great power States. The maintenance of realistic national interests of countries such as Brazil and Argentina require the adequacy of military strategic multidomain defense doctrine, with extensive use of Information Operations as the basis of their grand strategy.

AUTHORSHIP AND CONTRIBUTIONS

All authors participated equally in the development of the article.

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Defense Industrial Base and Armed Forces: potentialities and challenges in the context of Defense Economics

Base Industrial de Defesa e Forças Armadas: potencialidades e desafios no contexto da Economia de Defesa

Abstract: In Brazil, the consolidation of a Defense Industrial Base (DIB) made up by state and private, civil and military companies, focused on the development of strategic defense products (SDP), goes through constant challenges such as the irregular allocation of budgetary resources destined to the Armed Forces. Studies have shown the importance of the defense sector for industrial development, pointing out that innovations in the sector generate technological spillovers for the growth of the national economy. The methodology used is a case study, as this article analyzes the current context of the Armed Forces and the DIB and the phenomena that influence them from the perspective of the defense market-budget binomial.

Keywords: national defense; economics of defense; defense industrial base; armed forces.

Resumo: No Brasil, a consolidação de uma Base Industrial de Defesa (BID) composta de empresas estatais e privadas, civis e militares, voltada ao desenvolvimento de Produtos Estratégicos de Defesa (PED), passa por desafios constantes, como a irregularidade na alocação de recursos orçamentários destinados às Forças Armadas. Pesquisas têm demonstrado a importância do setor de defesa para o desenvolvimento industrial, apontando que as inovações no setor geram transbordamentos tecnológicos para o incremento da economia nacional. A metodologia utilizada é de estudo de caso, pois este artigo analisa o contexto atual das Forças Armadas e da BID, assim como os fenômenos que as influenciam sob a ótica do binômio mercado-orçamento de defesa.

Palavras-chave: defesa nacional; economia de defesa; base industrial de defesa; forças armadas.

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1 INTRODUCTION

Since World War II, military spending has been considered one of the relevant factors for the economic development of a country. Such development would be driven by huge investments in technological innovations and the production of goods with higher added value defined by the defense industry. Thus, the war industry was positioned as an important player in the national innovation system, particularly in countries whose public spending on defense and security is historically high, such as the United States and some European states.

However, the theme of national defense has little appeal and interest from society at large. Steinbrecher and Biehl (2020 *apud* SILVA, 2023) describe that the academic literature widely assumes that, despite some skepticism, most people do not know about defense policies and armed forces and, therefore, knowledge in this field is quite limited. Additionally, the theme has little political attraction and is not culturally studied.

In this sense, there is still resistance in sectors at different levels of the country regarding the understanding that defense is a theme of interest to all the Brazilians. Therefore, it is necessary to socialize and further develop the debate on national defense, inserting it into all structural spheres of the nation.

The National Defense Policy (*Política Nacional da Defesa* – PND) defines national defense as "the set of measures and actions of the State, with emphasis on military expression, for the Defense of the territory, sovereignty and national interests, against potential or explicit external threats" (BRASIL, 2020, p. 11, our translation).

Brazil, as an emerging power, has the challenge of being consolidated as a full power: to be endowed with military, technological, and industrial instruments vital to this condition. To this end, Brazil has sought to transform its Armed Forces, requiring the development of new capabilities to fulfill peace missions supported by the United Nations (UN).

Based on the PND and the National Defense Strategy (*Estratégia Nacional de* Defesa – END) (BRASIL, 2020), it is possible to identify future challenges for the Brazilian defense policy and for the Defense Industrial Base (DIB), such as, for example, the need to develop strategies to better structure the allocation of resources to the area, in order to foster industrial production in the sector, both within the state and private spheres.

The Defense transformation goes through the modernization of management and the reorganization of the DIB, aiming at national productive and technological capacity-building. The transformation of the Armed Forces has occurred in the light of the concepts and principles that guide Brazil's strategic insertion in the world, characterized by non-intervention, defense of peace and peaceful solution of conflicts, and its strategy of defense.

Therefore, it is important to have a better understanding of the role that public and private companies play in the industrial defense production – the institutional frameworks that rule the sector and encourage the industrial defense production – and which must be in full operation so that the Brazilian economics of defense may be a fundamental part of the national development process.

In this strategic light, Brazil lacks a defense industrial sector that, while supplying the government's domestic demand, is also able to export and generate goods and technologies that allow the spillover effects onto the civil industry.

Dosi (2006) observed that in the United States the technological spillover effects from military projects, such as the Internet and semiconductors, made the defense industry a major source of new technologies, including for the civil sector. The author also highlights that, even if these effects have not been constant over time, their main players continue to be a relevant part of the American innovation system. In this context, the following research question arises: In the context of public budget and defense market, what are the potentialities and challenges faced by the strategic projects of the Armed Forces and the Defense Industrial Base?

To answer that, we have used the case study methodology. According to Moraes, Pereira, and Franchi (2022), case studies have contributed to understanding social and political phenomena in the field of political science.

Thus, this research intends to contribute with research related to the area of defense in Brazil by filling gaps that may exist in the topic of defense economics, considering the importance of investments in strategic projects developed by the Armed Forces, and the increase in the DIB both in the production and national technological development and its expansion and insertion into the international market.

The work is divided into seven sections, including this introduction. The second section presents the DIB panorama. The third section is devoted to the characteristics and legal aspects of the Strategic Defense Companies (SDC). The fourth section lists the main policy documents on defense with special attention to the National Defense Strategy. Sections five and six deal with the focal point of this article, encompassing the topics on budget and defense market. In the last section, final considerations are made and further studies on the subject of defense economics are suggested.

2 DEFENSE INDUSTRIAL BASE

Dunne (1995) establishes that the DIB can be viewed as a sector or group of industries somewhat dependent on public defense spending, where the state also has some degree of dependence for self-sufficiency in the production of defense and warfare means.

The DIB is a core element of a state's defense. Its importance comes both from its strategic nature resulting from the production of the country's defense equipment, essential to ensure defense and its autonomy, and from its economic aspects related to the mastery of sensitive technologies, many with a dual character, and to the generation of innovation, of highly qualified jobs and of high added value exports.

Despite the reduced percentage of the defense budget for investments, the DIB has generated a significant number of direct and indirect jobs. Some companies, such as Embraer and Taurus, have been able to maintain a regular flow of exports, even with high and medium technology products, being an alternative for improving the Brazilian trade balance surplus.

In relation to the Gross Domestic Product (GDP), the DIB develops, produces, and commercializes products and equipment of high added value, fulfilling an important role in the national economic growth. The DIB accounts for 4.46% of the GDP, generating 2.9 million of direct and indirect jobs (BRASIL, 2021).

Moraes (2012) highlights four major companies in the defense sector in Brazil in the period 1975-2010, as they obtained the highest values of exports of war products, namely: Engesa, Embraer, Avibras, and Helibras.

Engesa, a company that went bankrupt in 1993, stood out for developing and manufacturing armored vehicles, with most of its production being exported mainly to Iraq. Embraer, founded in 1969, is one of the largest civil aircraft manufacturers in the world; their work is oriented to the production, development, maintenance, and marketing of fixed-wing aircraft focusing on the segments of regional and executive jets, as well as some military aircraft that are intended for early warning, control, remote sensing, aerial surveillance, and maritime patrol (MORAES, 2012).

Avibras, founded in 1961, initially stood out in the military segment by producing the Falcão aircraft intended for basic training. As of the 1980s, this company started developing missiles and rockets for the exclusive use of the military. However, despite its importance, it still remains behind Embraer and Engesa with approximately only 10% of the Brazilian exports in the last decades of the 20th century.

Helibras, created through an agreement between Brazil and France in the 1970s, is the only manufacturer in South America and one of the few companies in the Brazilian military sector that has predominantly foreign capital (MORAES, 2012).

Notably, the country has a relevant history of participation in the export market of military and defense materials, with some companies that stand out in the international market of this productive sector.

The structuring and strengthening of the DIB is a strategic priority for a country like Brazil that, in addition to having a considerable heritage of strategic natural resources that should be protected, is seeking an active insertion in the international political and economic scene.

For Brick, Sanches, and Gomes (2017), Brazil is a country whose DIB has potential to be developed but needs knowledge about its current and potential industrial capacity and potential strategic partners. Strategic partnerships with other countries in the defense sector are important for internal development and the gradual reduction of the dependence on external technology, as well as the increase of the Brazilian competitiveness in terms of Defense Products. Thus, the perspective of expanding demand for strategic defense products (SDP) offers an excellent opportunity for the development and strengthening of the DIB.

Brick (2011) emphasizes that, in strategic sectors considered critical, it is up to the state to finance the development of technologies and to assume full responsibility for their production when the economic conditions that ensure the sustainability of these companies cease to exist.

In this context, the DIB funding advanced in the year 2020. The Ministry of Defense and the Brazilian National Development Bank (BNDES) executed a protocol of intentions for the structuring of actions aimed at developing the Defense Industrial Base (DEFESANET,

2020). The initiative aims at fostering technological development and the Brazilian exports in the sector. The agreement is aligned with the Strategic Defense Action (*Ação Estratégica de Defesa* – AED-43) of the END-2020, that is, to improve funding mechanisms for the Defense Industrial Base (BRASIL, 2020).

Notably, Brazil keeps on assigning its work as a complement to the work of the private sector: "The state component of the Defense Industrial Base should, in principle, design and produce what the private sector cannot do profitably in the short and medium terms [...]" (BRASIL, 2020, p. 42; our translation). It is also up to the State to use its purchasing power to ensure conditions for sustainability and improvement of the DIB.

The END-2020 devotes a space to explain the direction that, ideally, should be adopted in state purchases, which should prioritize the use of products in the sphere of both defense and public security (BRASIL, 2020). Moynot (2010) points out that the DIB, as a strategic asset, should be guaranteed and preserved by the state, which implies the adoption of protection, development, and expansion measures. The author argues that

> The effect of scientific discoveries, advanced technologies, and the development of new fields of activities makes it strategically necessary for the state to directly or indirectly have appropriate financial instruments and an ability to promote strategic investments that pave the way for new industries. (MOYNOT, 2010, p. 133, our translation)

Sandler and Hartley (2007) clarify that even if one opts for the supposed simplicity of defining the DIB based on the set of companies that comprises it, which are found in different sectoral classifications with varied productive processes (technology, inputs) and applications and products for diverse use in the civil and military market, which are characteristics of Strategic Defense Companies.

3 STRATEGIC DEFENSE COMPANIES (SDC)

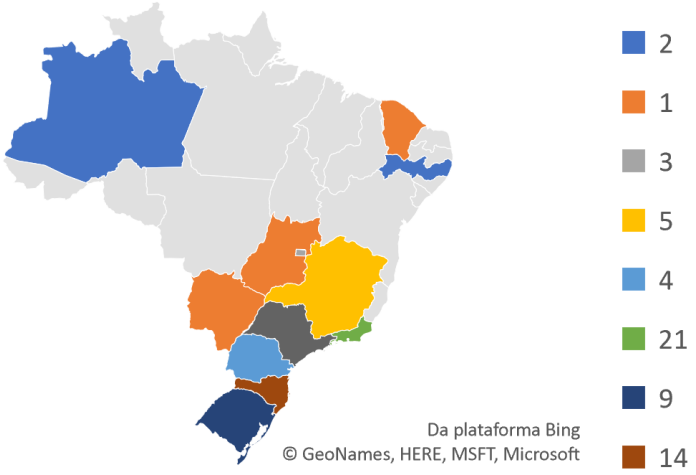
According to Law No. 12.598 of March 21, 2012 (BRASIL, 2012), which sets special rules for procuring, contracting, and developing defense products and systems, SDC is defined as any legal entity accredited by the Ministry of Defense upon meeting the following cumulative conditions:

> a) have as a purpose, in its corporate objective, the execution or conduction of research, project, development, industrialization, provision of the services referred to in art. 10, production, repair, conservation, revision, conversion, modernization, or maintenance of SDP in the Country, including the sale and resale only when integrated to the industrial activities mentioned above;
> b) to be based in Brazil with its administration and the industrial establishment, equivalent to industrial or service provider;
> c) to have, in Brazil, proven scientific or technological knowledge of their own or complemented by partnership agreements with Scientific and Technological

> Institution to carry out joint activities of scientific and technological research and development of technology, product or process, related to the activity developed, observing the provisions in clause X of the header;
> d) ensure, in its constituent acts or in the acts of its direct or indirect controller, that the set of foreign partners or shareholders and groups of partners or shareholders cannot exercise in each general meeting a number of votes higher than two-thirds (2/3) of the total number of votes that can be exercised by the Brazilian shareholders present; and
> e) ensure the continuity of production in the country. (BRASIL, 2012; our translation)

According to data from the Support Center of Defense Logistics Systems (CENTRO DE APOIO A SISTEMAS LOGISTICOS DE DEFESA, 2021) belonging to the Ministry of Defense, in Brazil there are 120 registered SDC, 69.2% (n = 83) of which are located in the Southeast region (57 in the state of São Paulo, 21 in the state of Rio de Janeiro, and 5 in Minas Gerais), 22.5% (n = 27) are located in the South region, 9 in Rio Grande do Sul, 14 in Santa Catarina, 4 in Paraná, and 8.3% (n = 10) are located in the states of Distrito Federal (n = 3), Amazonas (n = 2), Pernambuco (n = 2), Ceará (n = 1), Mato Grosso do Sul (n = 1), and Goiás (n = 1) (Figure 1).

Figure 1 – Strategic Defense Companies



Source: elaborated based on Centro de Apoio a Sistemas Logísticos de Defesa (2021)

Amarante (2012) suggests that the existence of the productive functional activities in the company's operational mode defines whether it can effectively be considered an SDC, that is:

> **Production**: activity of manufacturing products or components with the industry's basic technology, the one that characterizes its industrial sector, in this case aimed at military purposes.

> **Integration**: necessary activity for the industry that aims to work with weapon systems. Its competence reaches the level of design and manufacture of means of weapon and system integration.
> **Logistics**: procurement, supply and maintenance of weapon systems, military assets, and components.
> **Post-sale**: activity carried out after the sale of the military equipment, with the objective of maintaining it operational, including reengineering and the revision of production processes, among others.
> **Technological mastering**: constant and permanent activity with the basic technology of military systems and means, demonstrating that the company masters this technology. (AMARANTE, 2012, p. 29, emphasis added, our translation)

These characteristics reveal the scenario of SDCs' performance in the market, highlighting their obstacles, limitations and, at the same time, possibilities and capabilities of these ventures.

In times of transformation, clearly recognized by the companies involved in the national defense industry, it is necessary to develop and apply new strategies for future successes. Among these, the literature points to technological diversification and the establishment of national and international cooperation.

4 DEFENSE POLICY DOCUMENTS

Among the public policies aimed at national defense, the National Industrial Defense Policy (*Política Nacional da Indústria da Defesa* – PNID) (BRASIL, 2005) is charged with emphasizing the defense industry. This policy establishes the gradual decrease of dependence on foreign strategic defense products to develop and produce them domestically. In addition, it aims to increase the competitiveness of the Brazilian IDB in order to expand exports (BRASIL, 2005).

Chart 1 – Defense Documents and Objectives related to the IDB

Document	Objectives
National Policy on Industrial Defense – PNID (2005)	• Strengthen the Defense Industrial Base • Make society in general aware of the country's need for a strong Defense Industrial Base • Gradually reduce the dependence on external strategic defense products, developing and producing them internally • Expand the Armed Forces' capacity to acquire strategic defense products from the national industry • Improve the technological quality of strategic defense products • Increase the competitiveness of the Brazilian Defense Industrial Base to expand exports • Improve the capacity of industrial mobilization in the Defense Industrial Base

(continues)

Chart 1 – Continuation

Document	Objectives
National Policy on Defense – PND (2020)	• Foster the State's investment in advanced technology sectors • Promote the permanent upgrading and equipping of the Armed Forces with emphasis on the support of science and technology for the development of the DIB • Develop a DIB oriented towards achieving autonomy in indispensable technologies • Ensure that the industrial sector contributes to guarantee that the needs of defense products are met with technology under national control • Ensure the capacity of the DIB, including the mastery of dual use technology, to achieve the supply of defense products • Promote the integration of the South American defense industry as the object of measures that provide mutual development, as well as technological qualification and autonomy
National Defense Strategy - END (2020)	• Strengthen three sectors of strategic importance: space, cyber, and nuclear • Empower the defense material industry to achieve autonomy in technologies that are indispensable to Defense

Source: Brasil (2005, 2020)

The END (BRASIL, 2020) pays special attention to the DIB, emphasizing the prioritization of the development of independent technological capabilities, subordination of commercial considerations to strategic imperatives, and the use of defense technology development as a focus for the development of operational capabilities.

4.1 National Defense Strategy

The END is characterized by the adoption of a systematic orientation and the implementation of the measures established by the National Defense Goals in medium and long-term actions, presented by the PND (BRASIL, 2020).

The first edition of the END (BRASIL, 2008) brought several provisions regarding science, technology, and innovation (ST&I), with emphasis on what is considered to be opportunities to be explored supported by the identification and analysis of the main positive aspects and vulnerabilities of the country's defense structure, considerations that were reproduced in their entirety in the current edition of the END:

> (a) Greater integration between scientific and technological institutions, both military and civilian, and the national defense industry;
> (b) Definition of dual use research; and
> (c) Fostering research and development of products relevant to the defense. (BRASIL, 2008; our translation).

As for dual use defense equipment and systems, Longo (2007, p. 122) teaches that the term "dual use technologies" was coined by the Americans, and that "dual use technology

could be defined as that technology that can be used to produce or improve goods or services of civilian or military use" (our translation).

When designating the "era of dual use technologies", Dagnino (2010) notes that as it

> [...] increases the speed of introduction of innovations in the civilian sector, the military organizations of most countries producing weapon systems have turned to the civilian sector, both domestic and foreign, for dual use technologies and revolutionary scientific breakthroughs. (DAGNINO, 2010, p. 168, our translation)

For Herteman (2008) *apud* Melo (2015, p. 46), competitiveness is drawn by technological duality, which allows the intersection of civilian and military activities, in a "virtuous" circle. The author also states that duality has become fundamental to reduce the costs of defense materials and gain export markets, "contributing to the perennity of technological competencies in countries facing serious budget constraints" (MELO, 2015, p. 46, our translation).

It is worth noting that the END asserts that the Science, Technology and Innovation Policy for National Defense aims at fostering scientific and technological development and innovation in areas of interest to the national defense and this will occur

> [...] through national planning for the development of products with high technological content, with the coordinated engagement of civilian and military scientific and technological institutions (ICT), industry and universities, with the definition of priority areas and their respective technologies of interest and the creation of instruments to foster research on materials, equipment and systems of defense or dual use. (BRASIL, 2008; our translation)

The END brings guidelines, objectives and strategic actions. However, these are presented superficially, with emphasis on the need to associate the investment in defense as a diffusion of development and, as in previous documents, the progress of the related major strategic projects of each armed force (BRASIL, 2020).

In the technological and learning fields, the END points out that the future of national defense capabilities depends both on the development of technological apparatus and the training of human resources. Therefore, it is important to develop a policy to train researchers in the areas of basic and applied science to bring scientific research closer to activities related to technological development of the DIB (BRASIL, 2008).

One can notice the relevance pointed out by the END as to the need for strengthening the DIB; however, it presents some challenges to keep up with the growth in demand for Strategic Defense Products (SDP), in order to consolidate the DIB competitively: (1) increase investments in research, development, and innovation (RD&I); (2) promote tax isonomy with respect to imported products/materials; (3) expand participation in the domestic and foreign markets; and (4) strengthen the supply chain in Brazil (BRASIL, 2008).

Moreover, it would be important to seek the mastery of dual use technologies to favor the use of products for military and non-military purposes.

For Reppy (1999, p. 269, free translation), dual use technology "is at the core of the current American technological policy." In the United States, the demand and implementation of dual use technologies received a renewed impulse with the consolidation of the Homeland Defense policy, enacted after the attacks of September 11, 2001.

Nevertheless, the END highlights challenges in keeping up with the expansion of demand and consolidate the national defense industry in a competitive manner, which includes increasing investments in research and innovation; expanding participation in domestic and foreign markets; and strengthening the supply chain in Brazil.

According to Bohn (2014), the defense industry of a developing country, as is the case of Brazil, should fulfill four types of obligations: maintenance demands, such as maintaining the war infrastructure in times of peace and enabling increased production in times of crisis; quality maintenance, maximizing product quality at the lowest possible cost; production of systems that are unavailable from other suppliers; and the production of specific armaments in a given region, creating or maximizing comparative advantages through local demands.

For Lessa (2004), the paradigm of the defense industry that each country and national society practices is directly related to the stage of development of the productive forces of that particular nation.

The productive capacity of the DIB currently presents some important characteristics, including: partial technological autonomy; incomplete production structure; few national anchor companies with corporate, productive, and financial scale compatible with the standard of international competition; educational, scientific, and technological infrastructure that is still deficient; and, reduced densification of the production chain, which prevents greater productive and technological linkages (MELO, 2015).

In this context, the project of modernization and re-equipment of the Armed Forces, through its strategic projects, should be a priority for the State, enabling the expansion of national productive, technological, and competitive capabilities. International, bilateral, or regional partnerships are of special importance in this process.

Initiatives – such as the creation of the Secretariat of Defense Products (*Secretaria de Produtos de Defesa* – SEPROD) in the Ministry of Defense and the adoption of Law No. 12.598, of March 22, 2012 (BRASIL, 2012), which established a new framework for state and market activities in the field of the defense industry – indicate that progress has been made in the direction of reorganizing the DIB. In coordination with the Brazilian Agency for Industrial Development (*Agência Brasileira de Desenvolvimento* Industrial – ABDI), SEPROD is conducting a nationwide mapping with the purpose of diagnosing the capabilities and potentialities of the DIB and establishing industrial and procurement policies for defense products.

However, it is up to the State to strengthen the productive chain, and, thus, it should be devoted to the development of financing lines and specific guarantees for the DIB. The choice of industrial autonomy in defense matters is essential and should be a national priority.

5 DEFENSE BUDGET

In Brazil, one of the most noticeable impediments to the full development of the DIB concerns budgetary constraints (BRICK; SANCHES; GOMES, 2017). In relation to the permanent members of the United Nations (UN) Security Council and the set of emerging countries that form the BRICS (Brazil, Russia, India, China, and South Africa), the Brazilian national defense investments fall short of these countries.

Hartley and Sandler (1995, p. 6) conceptualize defense economics as "the study of resource allocation, income flow, economic growth and stabilization applied to Defense-related topics" (our translation). The topics covered by defense economics gain more or less relevance according to the need and interest of the international and national contexts.

The theme can draw on several approaches, including industrial organization, the vulnerability of strategic equipment, research and development potential and the effects on economic growth, including comparing them to other budgetary functions (MORAES; TERNUS; PINTO, 2020).

Despite the COVID-19 pandemic, in 2021, world military spending for the first time in history exceeded 2.1 trillion dollars (US$), according to a survey published by the Stockholm International Peace Research Institute (SIPRI). About 2.2% of the global GDP was directed to the military sector – a nominal increase of 6.1% when compared with 2020 and 0.7% in real terms, considering the change in inflation over the same period.

The amount allocated to the defense sector was approximately ten times higher than the revenue goal set by the World Health Organization (WHO) to combat the global health emergency (HARTMAN, 2022).

The leading countries are the United States (US$ 801 billion), China (US$ 293 billion), India (US$ 76.6 billion), United Kingdom (US$ 68.4 billion), and Russia (US$ 65.9 billion). These countries concentrate 61.8% from the total of US$ 2.1 trillion, while the sum of the others corresponds to 19.2% (Figure 2).

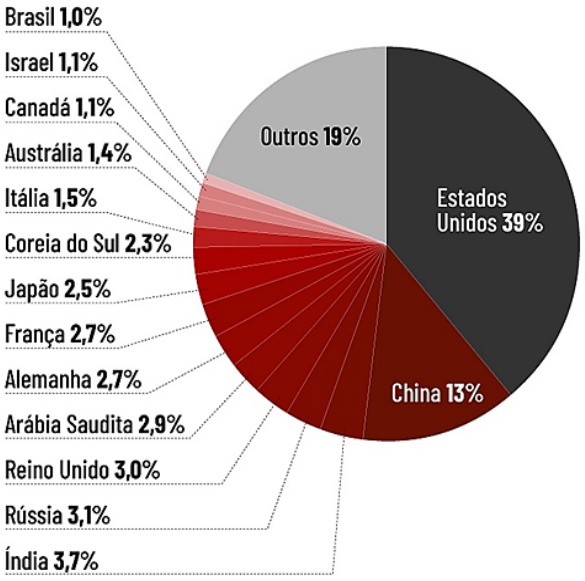
On December 15, 2022, the U.S. Senate passed a bill authorizing a record $858 billion for annual defense spending (CONGRESS.GOV, 2023). The figure exceeds that proposed by the US President Joe Biden by US$ 45 billion and is 10% higher than this year's (US$ 778 billion).

In the year 2021, Brazil ranked 15th, remaining distant from the other BRICS countries, with the exception of South Africa. At the same time, Brazil tops the list in Latin America, concentrating 1% of the total value of investments.

Moreover, by the year 2021, eight country-members of the North Atlantic Treaty Organization (NATO) reached the goal of investing 2% or more of GDP in their armed forces. The largest increase was in Japan, which allocated US$ 54.1 billion for defense in 2021 - 7.3% more than the year 2020 budget (HARTMAN, 2022).

Thus, despite the low percentage of the budget allocated to National Defense – which does not represent a low absolute value – one realizes that it is possible to invest in the development of the DIB through joint efforts between the Armed Forces and the public and private sectors, in order to achieve the potential for expansion of the national defense industry.

Figure 2 – Defense budget in relation to world spending (2021)



Source: Hartman (2022)

The Brazilian Army General Staff (BRASIL, 2019), through the Army Projects Office (*Escritório de Projetos do Exército* – EPEx), reveals what are the risks arising from the lack or unpredictability of budget for the Brazilian Army Projects, among which: non-fulfillment of contractual commitments causing loss of confidence in the relationship between the DIB and the Federal Government; losses for the DIB with the closing of assembly lines and supplying companies, generating unemployment and reflecting on social issues; discontinuity of programs due to unfeasibility of mobilization effort of the productive chains of the contracted companies; and increased costs of defense products.

Evidence points out that the DIB, before any strategic action, should recognize its capacities and limitations and prospect the future in an integrated way in the economic, social, and political dimensions. This implies the elimination of production activities for which there is no internal or external demand and that do not generate added value, defining which technological competence niches and areas of excellence demand investments.

Likewise, the most promising dual use technologies should be analyzed in order to identify those that can contribute the most to the consolidation of the sector's industries and give them a truly international dimension.

Regarding the Defense budget for 2023, the Annual Budget Law (*Lei Orçamentária Anual* – LOA) fixed the expenditure of the Ministry of Defense at 122.85 billion Reais (R$), of which R$ 8.66 billion (7%) are allotted for investments. The 2023 budget exceeds the previous year's R$116.43 billion by 5.2%, which represents a correction that practically only restores the inflation rate for the period.

It is worth mentioning that 77% of the budget is for the payment of personnel (salaries, pensions, and retirements of the Armed Forces' military personnel) (CONTROLADORIA-GERAL DA UNIÃO, 2023).

However, according to the 2023 LOA, the amount allocated to the main Navy, Army and Aeronautics projects totals R$ 5.2 billion (Table 2).

Table 2 – Armed Forces Projects – 2023 Budget

BRAZILIAN NAVY	
Construction of conventional submarines	681.3 million
Navy Nuclear Technology Systems Development	345.5 million
Construction of Shipyard and Naval Base for the Construction and Maintenance of Conventional and Nuclear Submarines	315.0 million
Construction of nuclear propulsion submarine	248.8 million
Construction of 500 tons Patrol Vessels (NPa 500t) – Macaé Class	58.9 million
Development of National Anti-Ship Missile	53.9 mi
Total	**1.7 billion**
THE BRAZILIAN ARMY	
Implementation of the Armored Forces Project	840.4 million
Implementation of the Integrated Border Monitoring System - SISFRON	345.5 million
Modernization and Strategic and Operational Transformation of the Brazilian Army	208.4 million
Implantation of the Military School of São Paulo (CMSP)	142.1 million
Implementation of the ASTROS Strategic Defense System	84.9 million
Implementation of the Army Aviation System	42.0 mi
Acquisition of Anti-aircraft Artillery Systems	17.9 million
Implementation of the Cyber Defense System for the National Defense	15.2 million
Implementation of the Army Strategic Program LUCERNA (Prg EE LUCERNA)	14.5 million
Expansion and Adaptation of Salvador General Hospital (HGeS)	9.6 million
Total	**1.7 billion**
BRAZILIAN AIR FORCE	
Acquisition of Fighter Aircraft and Related Systems – Project FX-2	1.37 billion
10 to 20 Ton Military Tactical Cargo Aircraft Acquisition - KC-390 Project	310.7 million
Development of Military Tactical Cargo Carrier from 10 to 20 Tons (KC-X Project)	172.7 million
Implementation of the Infrastructure for the Strategic Program of Space Systems (PESE)	4 million
Total	**1.8 billion**

Source: prepared by the author based on the National Congress (2023)

The Budget of Investment in the Ministry of Defense also covers the Naval Projects Management Company (EMGEPRON) and NAV Brasil Serviços de Navegação Aérea, in addition to other specific projects of the ministerial office.

The total revenue envisaged in the Annual Budget Law Project (PLOA) for 2023 is R$ 5.3 trillion, of which R$ 2 trillion are destined to the payment of interest and charges of the federal public debt and R$ 213.9 billion to investments.

In relation to the Gross Domestic Product (GDP), the estimated value in the PLOA 2023 is R$ 10.63 trillion, that is, the Ministry of Defense budget for 2023 corresponds to approximately 1.1% of the GDP.

We can see that the budget allotted to defense is still far short of what is recommended in the Strategic Defense Action (AED) 14 of the END (2020), whose goal is to "allocate budgetary and financial resources able to meet the needs of articulation and equipment for the Armed Forces, through the Annual Budget Law, at a level of 2% of the GDP" (BRASIL, 2020, p. 63; our translation). AED 14 is part of the Defense Strategy (ED-3), which aims to

> [...] enable the Defense Sector to better plan the use of budgetary resources, and thus rationalize their use, making defense expenditure more efficient. Additionally, it seeks to make the defense budget compatible with the country's size in the global scenario. (BRASIL, 2020, p. 63, our translation)

6 DEFENSE MARKET

Brick (2014) notes that defense industries operate in the defense, security, and civil segments; therefore, suppliers of these products usually operate in a competitive market. The civil segment follows traditional market laws of supply and demand, suppliers and buyers competing for the best value for money; however, market laws do not prevail in the defense segment.

The defense industry is very specific in that its size, structure, and trade are determined by the policy of the government, its main customer and regulator of the sector's exports. Such characteristics are known as monopsony, i.e., there are many suppliers, in the case of defense national producers of arms and ammunition, but only one customer, the Federal Government, unlike a monopoly in which there are many customers but only one supplier. If the other states are considered, the market can be seen as oligopsony, that is, without effective competition.

Dunne (2015) points out some characteristics of the defense market: emphasis on the performance of high-tech weapons rather than cost; risk borne by the government, which often funds research and development and in some cases provides capital and infrastructure investment; rules and regulations on contracts, to compensate for the absence of any form of competitive market and ensure public accountability; and emphasis on government contracts, rather than expanding supply in private markets.

Moreover, arms production is a laboratory of capitalist production methods. For Samuels (1996), in testing new methods, arms production takes industrial and economic risks that civilian enterprises would not take, i.e., military production [...] "increases the built-in

savoir-faire[1] of management, sales, and systems integration that can be built into products, and that feeds the technological infrastructure of the entire economy" (SAMUELS, 1996, p. 18, our translation).

The firms' competitive nature suggests that no strategy that can be freely replicated can ensure profitability rates above the market average. Vasconcelos and Cyrino (2000, p. 32) describe that, under these conditions, "for a firm to maintain high profitability, it must rely on permanent innovation strategies, derived from elements that are difficult for competitors to imitate" (our translation).

It has been observed that certain companies manage to sustain a superior performance, despite the continuous efforts of competitors to imitate their strategies, products, production methods, and distribution schemes (VASCONCELOS; CYRINO, 2000).

In this scope, the Brazilian arms industry has sought to increase its competitive potential with the development of additional weapon systems to export and expand its technologies to go beyond domestic military needs, in order to occupy space in the international market. Such strategy is supported by the news published on April 1, 2020, which reports that "the Swiss company, SIG Sauer, manufacturer of the weapons, would be in advanced negotiations with Indústria de Material Bélico do Brasil (IMBEL), the main supplier of ordnance to the Brazilian Armed Forces, to enter into a major partnership" (PORTAL GOV.BR, 2020). According to Infodefensa (2021), Imbel plans, in partnership with SIG Sauer, to begin production of the P320 pistol at the Itajubá Plant in Brazil.

Regarding exports, Brazil is not an established producer in the global trade of conventional weapons. In the ranking of world exporters, in the period from 2010 to 2015, the country occupied the 23rd position, while in the ranking of importers Brazil occupied the 26th position, with a moderate participation in the global transactions of the arms industry. However, it is worth analyzing the markets in which Brazil has a participation.

In the ranking of the largest buyers of Brazilian arms, from 2010 to 2015, 3 are from Asia, 5 from Africa, and 6 from Latin America (Bolivia, Chile, Colombia, Ecuador and Paraguay). One of the benefits for Brazil as a supplier of armaments to its neighboring countries, is the intensification of its influence over the purchasing countries, contributing to maintain the regional balance of sovereignty. As a buyer, the benefits include technology transfer and industrialization for military purposes.

Also, South American countries often cannot afford the costs or maintenance of advanced high technology systems, which leads Brazil to occupy a niche in the market of medium and low technology items, lowering the price of goods, and attracting peripheral buyers.

Regarding imports from Brazil, the largest volume comes from Germany, France, USA, Israel, Italy, and Russia, which are mostly established powers in the international market of this industry. Defense procurement is understood as the process of "attending to needs from a wide range of options, from the national development of the product to the purchase of ready

1 know-how, knowledge.

and finished equipment in the international market" (LONGO; MOREIRA, 2013, p. 295, our translation).

For the authors, the demands for goods and services that justify a sectoral system of defense innovation gain tangibility in the PED, such as platforms and combat systems that make up the material base of the national defense system. Due to the high technological standard of these products, some are considered strategic and generate special technological orders to the productive sector, particularly from the IDB, through government purchases (LONGO; MOREIRA, 2013).

Investments are characterized as long term and high risk, often leading government defense managers to opt for obtaining products abroad, thus worsening the technological dependence (LONGO; MOREIRA, 2013). The authors also point out that the SDC suffer from: lack of incentives; low levels of investment in equipment for the Armed Forces with the consequent lack of continued demand; lack of a regulatory framework that favors domestic industry in international competition; absence of an integrated system of planning and defense procurement that facilitates the articulation with the sector and provides long-term predictability for investments in infrastructure and R&D; and difficulty in obtaining resources for the acquisition of opportunities abroad.

Likewise, the obsolescence of existing military employment materials (MEM) of the Armed Forces, as end-users of the SDP, also observe external technological dependence and the lack of continuity in investments for the re-equipment and modernization of the forces, as well as the difficulty in meeting targets, deadlines, and project specifications by companies in some projects.

Thus, the demand for defense products is determined by strategic and geopolitical factors of the States, rather than by economic logic, making this the main component to define the production of companies.

In order to reduce the impact of the low demand of the Defense Industrial Base, one of the strategies pointed out by Hartley (1999), is for the state to use its regulatory and purchasing power (defense procurement) to define the structure, the size, the companies that enter or leave the base, the technological goals, prices, and profits of this industrial sector.

Having said this, it can be observed that the DIB, composed of the SDC and strategic defense (SD) is a sector of great relevance to Brazil, both economically and socially. However, it still depends on political decisions that aim to solve existing problems and support the needs presented by the sector.

7 FINAL REMARKS

Considering the theme of this article – economics of defense – it is observed that the governmental and industrial sectors and the academic environment, focused on science, technology, and innovation, should be integrated in order to ensure the supply of defense products supported by domestic technologies. Such technologies are acquired by stimulating and fostering, synergistically, the defense industries and the academia.

Regarding the DIB, dual use technologies are essential to obtain the supply of defense products aiming at the technological autonomy of Brazil. Promoting DIB tends to stimulate economic growth since it produces jobs and expands useful products for both the civil and military sectors. Likewise, the DIB competitiveness should be leveraged, aiming at the export of military goods, services, and technologies.

Therefore, it is up to the government to think strategically about these issues, ruling the control of access to national products to other countries via exports. It is worth mentioning that the civil-military technological duality may restrict the possibility of controlling foreign trade. Furthermore, international policies define the importance of technological standards with a view to sovereignty.

In this context, it is up to the State to use its purchasing power to ensure minimum conditions of sustainability and strengthening of the DIB, so that the production chain does not depend on the export policy and commercialization of dual products.

On the other hand, when supplying defense products to the international market, it is necessary to follow global product standardization, such as the National Stock Number of the North Atlantic Treaty Organization (NSN/NATO), imposing a balance between internal needs and access to the external market.

The relevance of effective government action is also evident in the regulatory definitions of the defense market. The specifications and hypotheses of use of military equipment are defined by the doctrines of the Armed Forces which, in turn, impact the formulation of requirements, certifications, and technologies of these products.

No less important, in geopolitical terms, is the non-participation of Brazil as a member of an international military block, which can make it hinder the participation in international competitions, depending on the level of economic, technological or operational relevance of the products, equipment, or materials.

Economically, the search for new markets is one of the greatest challenges for the DIB and is a relevant factor for its development. Thus, the State should be a facilitating and supporting agent for financing programs, research projects, development, production, acquisition, and commercialization of defense products to provide greater confidence to potential international buyers.

In this context, this article achieves its objective by identifying the potentialities and challenges of the Defense Industrial Base and the Armed Forces from the perspective of the defense budget-market binomial as an element that induces economic and social development and guarantees national sovereignty.

As the theme of economics of defense is a fertile and inexhaustible field of research possibilities both nationally and internationally, or comparatively, under different approaches and methodologies, it is suggested that new studies might encompass the efficiency of public expenditures in the field of Defense, the impact of strategic defense projects on social and economic aspects, new business models in the national and international Defense market, including empirical research that can be conducted with the SDC.

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Greece and Turkey's neorealist stance in the eastern Mediterranean Sea and Aegean Sea maritime disputes

La postura neorrealista de Grecia y Turquía en las disputas marítimas en el mar Mediterráneo oriental y el mar Egeo

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Abstract: Maritime disputes between Greece and Turkey in the Aegean Sea and the eastern Mediterranean Sea reflect the conflicts in the history of formation of both States. These disagreements acquired new dimensions with the discovery of mineral resources on Cyprus' Continental Shelf, the organization of the East Mediterranean Gas Forum (EMGF) and the announcement of the creation of the *EastMed* pipeline, which has the participation of Greece, Cyprus and Israel; and the exclusion of Turkey from this project. In contrast, Turkey values the expansionist policy of the *Mavi Vatan* (Blue Homeland), which seeks a new geopolitical positioning. This article aims to analyze the maritime disputes between Greece and Turkey for the use of this pipeline, based on realism theory in international relations. In this context, we will analyze the extent to which the neorealist stance of both States interferes with their relations with the European Union (EU), with the North Atlantic Treaty Organization (NATO), with the resolutions of the United Nations Convention on the Law of the Sea (UNCLOS) and with maritime disputes of the eastern Mediterranean Sea. To this end, we used a qualitative descriptive methodology through bibliographic research on the strategic relevance of the Aegean Sea and the eastern Mediterranean Sea and the challenges to maintain the stability of the region considering the particular interests of Greece and Turkey. In this sense, we used reports from the European Parliament, the US Congress on NATO, and articles on the maritime disputes in the region. The results show the extrapolation of the differences between the two States involving other actors in the maritime disputes, the establishment of international bilateral and multilateral agreements, the increased tension in the eastern Mediterranean Sea and, consequently, the adoption of a moderate stance by all actors involved in order to achieve a peaceful solution.

Keywords: Greece; Turkey; Cyprus; Aegean sea; eastern Mediterranean sea.

Resumen: Las disputas marítimas entre Grecia y Turquía en el mar Egeo y el mar Mediterráneo oriental reflejan los conflictos de la historia de formación de ambos Estados. Estos desacuerdos adquirieron nuevas dimensiones con el descubrimiento de recursos minerales en la Plataforma Continental de Chipre, con la organización del Foro de Gas Natural del Mediterráneo Oriental (EMGF) y el anuncio de la creación del oleoducto *EastMed*, que cuenta con la participación de Grecia, Chipre e Israel; y la exclusión de Turquía en este proyecto. En cambio, hay una apreciación, por parte de Turquía, de la política expansionista de *Mavy Vatan* (Patria Azul), que busca un nuevo posicionamiento geopolítico. Este artículo pretende analizar las disputas marítimas entre Grecia y Turquía para el uso de dicho oleoducto, a la luz de la teoría realista de las relaciones internacionales. En este contexto, se analizará hasta qué punto la postura neorrealista de ambos Estados interfiere en sus relaciones con la Unión Europea (UE), con la Organización del Tratado del Atlántico Norte (OTAN), con las resoluciones de la Convención de las Naciones Unidas sobre el Derecho del Mar (CNUDM) y en las disputas marítimas del mar Mediterráneo oriental. Para ello, se utilizó una metodología descriptiva cualitativa por medio de investigación bibliográfica sobre la relevancia estratégica del mar Egeo y del mar Mediterráneo oriental y los desafíos para mantener la estabilidad de la región frente a los intereses particulares de Grecia y de Turquía. En este sentido, se utilizaron informes del parlamento europeo, del congreso estadounidense sobre la OTAN y artículos sobre las disputas marítimas de la región. Los resultados fueron la extrapolación de las diferencias entre los dos Estados, involucrando a otros actores en las disputas marítimas, la realización de acuerdos bilaterales y multilaterales internacionales, el aumento de la tensión en el mar Mediterráneo oriental y, en consecuencia, la adopción de una postura moderada de todos los actores involucrados a fin de lograr una solución pacífica.

Palabras clave: Grecia; Turquía; Chipre; mar Egeo; mar Mediterráneo oriental.

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1 INTRODUCTION

The relations between States are anarchic. In general, neorealist theory seeks to explain these relations between States based on the structure and influence of the international system on them (LAMY, 2005). In this context, we selected the relations between Turkey and Greece in the maritime disputes in the eastern Mediterranean Sea and Aegean Sea.

It is important to note that the Aegean Sea and the eastern Mediterranean Sea are situated in a strategic position, since they materialize a geopolitical intersection between the west and the east, being natural confluences of maritime communication lines from Europe, Asia and Africa (AUTRAN, 2021).

The Aegean Sea plays an important role in the history of these two countries. It was the scene of disputes over rights to maritime spaces over time. In addition, the Aegean Sea has more than 2500 islands, which increases the complexity of negotiations from the legal perspectives of disputes.

In 1982, there was the creation of the *United Nations Convention on the Law of the Sea* (UNCLOS), which sought to regulate, at an international level, the duties and rights regarding the maritime spaces of States. Although Greece is a signatory to the Convention, Turkey is not. This situation hinders negotiations in this forum and helps to demonstrate the anarchic character of the international system, as it justifies the States' pursuit of power.

Despite dissent between Turkey and Greece, both States are members of the North Atlantic Treaty Organization (NATO). Participation in this common treaty has not prevented strife between the two States in recent history. There were even threats of use of force during the Invasion of Cyprus (1974), as presented below in this article.

In 2020, Greece and Turkey again found themselves on the brink of war because of opposition and exercise of sovereignty over the waters of the Aegean Sea and eastern Mediterranean Sea due to the then recent discovery of mineral resources. Nevertheless, once again, peace was kept.

Turkey and Greece have historical differences that are related to their respective formation processes. This article aims to explain, based on neorealist theory, how these relations occurred over time, especially since the dissolution of the Ottoman Empire, and how they have recently been aggravated.

Accordingly, the objective of this research is to analyze the relation between Greece and Turkey concerning the relevance of the Aegean Sea and eastern Mediterranean Sea, as well as the challenges to maintain the stability of the region considering the particular interests of each of these States.

The relation of these States was analyzed from the perspective of Waltz's neorealism theory, whose central objective is to explain the main causes of war in international relations, advancing an analysis that enables both the understanding of international conflicts and the political construction of peace.

To this end, we used a qualitative descriptive methodology, with the help of bibliographic research, focused on reports from the European Parliament, from the US Congress on NATO, and on articles on the maritime disputes in the region. The results show the extrapolation of the differences between the two States involving other actors in the maritime disputes,

the establishment of international bilateral and multilateral agreements, the increased tension in the eastern Mediterranean Sea and, consequently, the adoption of a moderate stance by all actors involved in order to achieve a peaceful solution.

2 THEORETICAL FRAMEWORK

Kenneth Neal Waltz (1924–2013) is an American political scientist, who defended, in 1954, at Columbia University, his doctoral thesis on the theme *Man, the State and the International System in Theory of the Causes of War*[1]. At that time, he introduced the development of the neorealist or structural realist theory of international relations, which resulted in the publication of the book *Man, the State and War: a theoretical analysis*,[2] in 1954, enhancing his theory, in 1979, through the book *Theory of International Politics*.[3]

Waltz's neorealist theory has as its central objective the explanation of the main causes of war in international relations, advancing an analysis that enables both the understanding of international conflicts and the political construction of peace. Thus, founded on the assumption that there is a dynamics of mutual constitution between the occurrence of wars and the formation of States, we seek to investigate the three images of the neorealist theory of international relations — man, States, and the State system — in order to analyze the causes of contemporary wars and how they influence the structuring of the State system, which is the foundation of the international system (WALTZ, 1959).

According to Waltz (1959), the understanding of war can be divided into three images[4]. The first concerns the philosophical discussion about human nature and man's influence on the occurrence of war. In the second image, the author focuses on the action of States, understood as the maximum structure of society, these being the main agents that produce war. In the third image, in turn, there is the affirmation of the existence of an anarchic international system, in which States interact with one another in search of a balance of power.

The third image is central to the understanding of war, and this image is influenced to a greater or lesser extent by the other images (WALTZ, 1974). In this sense, the contemporary international context – volatile, uncertain, dynamic and ambiguous – shows the same inclination to war pointed out by Waltz.

The late 20th century saw the rise of new actors on the international political scene, such as the United Nations (UN) and the European Union. However, the transnational aspect of the UN does not change the anarchic character of the international system, since the institution is composed of States that develop policies and apply them to other States. Similarly, the

1 Original title: *Man, the State and the State System in Theories of the Causes of War*.

2 Original title: *Man, The state and war: A Theroretical analysis*.

3 Original title: *Theory of international politics*.

4 The author points out that image cannot be confused with level. According to him, the term image of analysis suggests the way a figure appears to each one, pointing out that each one has a particular view of the world. From the moment it is found that international politics cannot be observed directly and truly, the term image refers to what is seen from different perspectives.

European Union seeks cooperation between member states, but faces new challenges, such as Turkey's request to enter and the United Kingdom's unilateral decision to exit.

Since the purpose of States is the practice of war, protection, extraction, application of justice and production, the structural logic of the preservation of States still to date follows the fine line between war and political action (MAIA; BARBOSA, 2013). According to Waltz (1974), States wage wars because nothing prevents them from waging wars. Although — in a historical retrospective — direct casus belli have varied, war remains an efficient coercive tool of States. In this regard, even when there is no conflict, States move their policies to prepare for the clash, given the need to preserve the sovereignty, nationalism and security that sustains them, maintaining the balance of power and their *status quo* in the international political arena.

3 HISTORY OF THE RELATIONS BETWEEN GREECE AND TURKEY

Turkey and Greece are two States located southeast of Europe and separated by the eastern Mediterranean Sea and the Aegean Sea as represented by Figure 1 (CENTRAL INTELLIGENCE AGENCY, 2021). Turkey has a land area of 783,500 km^2 and a population of 82 million people, while Greece has an area of 132,000 km^2 and a population of 10.6 million.

Figure 1 – Aegean Sea and Eastern Mediterranean Sea

Source: SEQUEIRA, 2016

The two countries, neighboring each other geographically, have relations marked by alternating periods of hostility and peace. In effect, after the Greek War of Independence (1821-1832) against the former Ottoman Empire, four major conflicts between Turks and Greeks can be noted:

the Greco-Turkish War of 1897, the First Balkan War (1912-1913), the persecutions during World War I (1914-1918), and the Greco-Turkish War (1919-1922) (GRECO-TURKISH..., 1998).

The first conflict, the Greco-Turkish War or Thirty-Day War (1897), occurred in a context of increasing Greek concern over the conditions of its inhabitants on the Turkish-ruled island of Crete, where relations between Christians and Muslim rulers progressively deteriorated (WAR of GREEK..., 1988).

The First Balkan War, in turn, lasted from October 1912 to May 1913, involving actions of the Balkan League – the former kingdoms of Bulgaria, Serbia, Greece and Montenegro – against the Ottoman Empire. The war resulted from the aspirations of nationalist States that wished to incorporate territories whose majority of the population claimed to belong to some of those nationalities, which, however, remained under the rule of the Ottoman Empire (HALL, 2014; WAR OF GREEK..., 1988).

In turn, during World War I, there was systematic persecution of the Christian Greek population of Anatolia, instigated by the Ottoman Empire and the Turkish nationalist movement for religious and ethnic reasons. Hundreds of thousands of Ottoman Greeks died in this period and the surviving refugees, upon returning to Greece, caused an increase of approximately a quarter to the population of that country (BLAINEY, 2009).

Current maritime disputes stem largely from the 1923 Treaty of Lausanne, which ended the Greco-Turkish War of the early 1920s. The treaty established the independence of the Turkish territories and balanced the interests of the two countries in the Aegean Sea, delimiting maritime areas, demilitarizing Greek islands and advocating mutual benefits for Greece and Turkey. Thus, there was a stabilization of relations in the following decades, which remained until the recent maritime discussions returned.

Subsequently, the 1947 Treaty of Paris between Italy and the Allied Powers, including Greece, reverted possession of the Dodecanese islands in the Aegean Sea, to Greece, as compensation for losses in World War II (1939-1945), while maintaining a limitation to the militarization of the islands. These islands had already been Turkish in the 16th century, but came into possession of Italy after the Italian-Turkish War of 1912. Hence, the Treaty of Lausanne, which had confirmed Italian ownership of these islands, would have been, in a way, replaced by the provisions of the Treaty of Paris. As a result, the islands on the southwest coast of Turkey came to be seen as a strategic problem for the Turks, compromising, with the Treaty of Paris, the balance provided by the Treaty of Lausanne (MANN, 2001).

4 THE IMPORTANCE OF GREEK AND TURKISH PARTICIPATION IN NATO AND THE EU

NATO, led by the United States of America (USA), was initially created as a collective defense alliance to oppose, during the Cold War[5], the Union of Soviet Socialist Republics

5 The Cold War arose in the context of a bipolar international order characterized by confrontation between the US and Russia (former USSR) in a pursuit of spheres of influence. In this case, considering the period between the presentation of the Truman Doctrine to the US Congress in 1947, with the foreign policy directives of containment of Soviet expansionism, and the fall of the Berlin Wall in 1989, which preceded the dissolution of the former USSR in 1991.

(USSR), whose largest representative was Russia. Although geographically closer to the USSR, both Turkey and Greece joined NATO in 1952. Therefore, until the end of the Cold War, the participation of both countries in the alliance contributed so diplomatic deadlocks were resolved within the scope of political association against a common enemy. After the dissolution of the Warsaw Pact, the main threat to NATO, the organization became, in addition to a military alliance, a treaty to represent the attempt to guarantee the collective security of Europe (MANN, 2001).

Turkey is important for NATO, as the country helps to contain Spykman's *Rimland* in Eurasia, directly confronting Russia (KAPLAN, 2013)[6]. This perspective is pointed out by American experts on issues related to Turkey, according to the excerpt:

> Turkey's location near various global access points has made the continued availability of its territory — for **parking and transportation of weapons, cargo and personnel — valuable to the United States and NATO**. From Turkey's perspective, NATO's traditional value has been to mitigate its concerns about invading neighbors. Turkey initially turned to the West largely as a reaction to the post-World War II aggressive stance of the Soviet Union. In addition to Incirlik Air Base near the city of Adana in southern Turkey, there are other important US/NATO sites, with an early missile alarm in eastern Turkey and a NATO ground forces command in Izmir. Turkey also controls access to and from the Black Sea through its straits[7]. (ZANOTTI; THOMAS, 2021, p. 3, our translation, emphasis added)

However, according to Kaplan (2013), it is an ally that is not totally faithful to the treaty. In March 2003, the Turkish parliament voted against the deployment of troops of the United States — the largest power in NATO — on its territory for the invasion of Iraq, showing some resistance to US interests.

In addition, in 2017, Turkey began the process of acquiring a Russian surface-to-air defense system, designated S-400, and the possible purchase of Russian fighter aircraft, in a rapprochement between the countries. According to Zanotti and Thomas (2021), this situation required a firm stance of the US, which announced the non-supply of the F-35 *Joint Strike Fighter* aircraft to Turkey and, additionally, stopped manufacturing the components for these aircraft.

6 According to Spykman, the *Rimland* is functionally a vast region, south of Russia, that serves as a buffer zone or blockade of conflicts between land power, represented by Russia, and maritime power, represented by the States that exercise dominion at sea. In Europe, this phenomenon is represented by the millennial wars that occurred between Eastern Europe and the Russians in the buffer region of Eastern Europe. In the European East, Russia has fought against the Turks and English in several attempts to reach the ocean and be able to project itself through the sea (TOSTA, 1984).

7 Original text in English: "*Turkey's location near several global hotspots has made the continuing availability of its territory for the stationing and transport of arms, cargo, and personnel valuable for the United States and NATO. From Turkey's perspective, NATO's traditional value has been to mitigate its concerns about encroachment by neighbors. Turkey initially turned to the West largely as a reaction to aggressive post-World War II posturing by the Soviet Union. In addition to Incirlik Air Base near the southern Turkish city of Adana, other key U.S./NATO sites include an early warning missile defense radar in eastern Turkey and a NATO ground forces command in Izmir. Turkey also controls access to and from the Black Sea through its straits pursuant to the Montreux Convention of 1936*".

The S-400 agreement also triggered US sanctions. Former US President Donald Trump delayed such sanctions, while trying to persuade Turkey to refrain from operating the S-400s. The way the US responded to Turkey's acquisition of the S-400 could affect U.S. arms sales relative to other key partners that have purchased or will purchase advanced weapons from Russia, including India, Egypt, Saudi Arabia, and Qatar. However, according to the analysts Zanotti and Thomas (2021), it is not clear how sanctions against Turkey could affect the US defense economy, trade and purchases.

Turkey, despite being a democracy and a NATO member State, has consoled itself for years with the hope of joining the European Union (EU), a fixation that the Turkish authorities have made clear to the economic bloc. However, in the first decade of the 21st century, it became clear that Turkey may never become an effective member of the European Union for an obtuse reason based on geographical and cultural determinism: the country is Muslim, which makes it unwanted, as it could be the largest gateway to Europe (KAPLAN, 2013).

For its part, Greece is also important for NATO. The country has special relevance due to the possibility of military use of its islands. Unlike Turkey, Greece has remained more faithful to the treaty, since it has not been the protagonist of the disputes with Turkey. However, due to disagreements as to the Cyprus issue, it temporarily withdrew from NATO between 1974 and 1980. According to the then Greek Prime Minister, Constantine Karamanlis (1907-1998), faced with the occupation of Cyprus by Turkey, in 1974, with the use of NATO military material, the only ways left to resolve the deadlock would be the following possibilities: "Withdraw from the Treaty or start a war with Turkey" (STEARNS, 1992, p. 68).

The disputes between Greece and Turkey cause several problems and vulnerabilities to the organization. These differences have historical origins and were not resolved when both countries joined the organization, nor even when the treaty represented defense against a common enemy, the former USSR, nor over more than half a century as member States. Thus, disputes between the two NATO member States continue to exist, as follows:

> The coincidence of NATO's national and military missions explains why Greece and Turkey were able to make significant adjustments to their deployment of defense forces and plans without being directly challenged by NATO's Military and Defense Planning Committees. Although the more casual scrutiny of Greek and Turkish battle orders clearly showed that their forces in the Aegean theater were deployed primarily against each other, not against the Warsaw Pact, NATO chose to treat them as forces executing a national defense mission consistent with NATO's plans so as not to raise the most bothersome question of what threat they were defending themselves from[8]. (MANN, 2001, p. 55, emphasis added)

8 Original text in English: "*The coincidence of their national and NATO military missions explains why Greece and Turkey were able to make significant adjustments in their force deployments and defense plans without being directly challenged by NATO's Defense Planning and Military Committees. Although the most casual scrutiny of Greek and Turkish orders of battle clearly showed that their forces in the Aegean theater were deployed primarily against each other, not the Warsaw Pact, NATO chose to treat them as forces executing a national defense mission consistent with NATO plans and not to raise the more awkward question of what threat they were defending themselves against*".

5 THE SITUATION INVOLVING CYPRUS

After the World War II period, ethnic problems arose between Turks and Greeks due to religious differences between Muslims and Christians. In 1955, these oppositions were materialized in protests in Istanbul over ethnic issues in Cyprus, first when it was under British rule and later when it became an independent State. In 1959, an agreement was negotiated between the United Kingdom, Turkey and Greece to guarantee the independence of Cyprus and, consequently, the interests of the communities of these countries.[9]

In 1974, a group of Greek citizens of right-wing political party orientation, supported by the military dictatorship then in force in Greece, tried to take control of Cyprus, which led to Turkish intervention, declaring itself guarantor of rights on the island. Thus, Turkey invaded northern Cyprus, occupying about 40% of the island's territory, dividing it under the pretext of protecting the Turkish Cypriot minority, escalating military tensions between Turkey and Greece. To this day, the Turkish Republic of Northern Cyprus is recognized only by Turkey, while the Republic of Cyprus is recognized internationally.

Thus, there was again a recrudescence of historical rivalries between the two countries, with Cyprus being the pivot of the aggravation of these disputes, which still persist. Tensions culminated in cancellation of the cooperation pacts between Greece and Turkey, causing the collapse of the Balkan Pact[10]. In 1976, they signed the Berne Protocol, in which they agreed that they would not exploit the maritime areas beyond their sovereignty.

6 THE CATALYST OF CONTEMPORARY DISPUTES

Considering growing demands, especially in the economic sphere, there were increased efforts to strengthen legal regulation and establish levels of jurisdiction with relative international consensus. In 1982, UNCLOS was introduced, under the aegis of the UN, which initially had 116 signatory States, including Brazil, and defined the rights and duties of the States as to the maritime spaces (SOUZA, 2018).

UNCLOS, despite the need to reconcile the interests of different States, managed to standardize maritime use. It standardized criteria for defining maritime regions subject to the levels of sovereignty of the coastal State, which diminishes as the distance of these regions from the coastline increases. The defined regions were: Territorial Sea (TS), Contiguous Zone (CZ), Exclusive Economic Zone (EEZ), Continental Shelf (CS) (SOUZA, 2018).

9 The Treaty of Guarantee (1960) was established in the context of Cyprus' independence from British rule, which had lasted since 1914. This treaty was made possible after the Greek and Turkish communities reached an agreement on a constitution for the country, giving Great Britain, Greece and Turkey the right to intervene in Cyprus, as well as allowing the maintenance of British sovereignty over two military bases in Cyprus (MARCUS, 2011).

10 Because Yugoslavia turned to the West after a breakaway from the former USSR in 1948, a new front was opened in the Cold War. Thus, agreements were made by the Yugoslavs with Greece and Turkey, creating the Balkan Pact, initiated as a political agreement that was concluded in Ankara (Turkey), in February 1953. Through this pact, Yugoslavia was indirectly included in the Western defense system, strengthening its security (TERZIC, 2016).

With technological advancement, States felt the need to expand their waters to ensure security and exploit marine and subsurface marine resources. This extension of areas under sovereignty, territorial waters or TS, with a width of 12 nautical miles (NM), and under jurisdiction, the CS and the EEZ represent sources of several disputes, including those of the Aegean Sea and Eastern Mediterranean Sea.

The concept of EEZ, which allows for the exercise of jurisdiction over the 200 NM of the baseline of the neighboring State, was recognized by the United Nations Convention on the Law of the Sea, concluded in Montego Bay, Jamaica, in December 1982. However, many countries acted before the signing of the convention, to establish their EEZs, such as France, which did so in 1976. These developments disturbed the relative stability of the Aegean Sea, respected since the end of World War II, and led to controversy regarding territorial and continental shelf waters, especially between Greece and Turkey.

In effect, there are two opposing historical realities that coexist in a mixture of reconciliation and resentment. The territorial division resulting from the Treaty of Lausanne and from the Treaty of Paris on February 10, 1947 seemed relatively stable (MANN, 2001).

Greece has approximately 2,500 islands in the Aegean Sea. Therefore, the establishment of an extension of TS, as provided for in UNCLOS, that is, with 12 NM, would give it control of 71% of these territorial waters, due to the existence of these islands, which would make it impossible for Turkish ships to reach the Mediterranean Sea without crossing Greek territorial waters. Historically, Greece extended its territorial waters to 6 NM by means of a law instituted in September 1936. Therefore, Greek territorial waters cover 43.5% of the Aegean Sea, while Turkish territorial waters represent only 7.5%. With UNCLOS, the high seas area would be reduced from 49% to 19.7%. Consequently, if the two countries established EEZs, as defined by the convention, the remaining space (19.7%) would fall entirely under the jurisdiction of Athens (REPUBLIC OF TÜRKIYE, 2021).

This is one of the factors that explain why Turkey always exerted pressure on its neighbor, claiming that the extension of Greek territorial waters to 12 NM would represent a *casus belli*[11] (REPUBLIC OF TÜRKIYE, 2021). The Turkish Parliament endorsed this position with a resolution approved in June 1995, shortly after the ratification of the UNCLOS by Greece. The difficulty arises from the fact that, subject to the Convention, ships of all States, whether coastal or land-locked, enjoy the right of innocent passage through the territorial sea of another State. This right involves restrictions for military vessels and submarines, which are required to sail on the surface and can be regulated by the coastal State (MANN, 2001). Thus, with the 12-NM extension of Greek territorial waters in the Aegean Sea, Turkish warships coming from the Bosphorus Strait or Smyrna would be subject to the limitations of the right of innocent passage or even to the regulations adopted by Athens.

In November 1973, the Turkish government authorized fuel research zones for the Turkish State Petroleum Company in the area located between the Greek islands of Lesbos, Skyros, Limnos and west of Samothrace. In July 1974, Turkey issued new permits extending

11 *Casus belli* is an expression to designate a fact considered sufficiently serious by the offended State to declare war on the allegedly offending State.

this zone to the west and claimed a new narrow portion of the continental shelf located between the Greek islands of the Dodecanese and Cyclades. Greece, for its part, strongly protested against these attitudes. Turkey, however, sent oceanographic ships to the contested area: the Çandarli in May-June 1974; and the Sismik I in August 1976, whose mission led the two countries to the brink of armed conflict.

Their positions can then be summarized as follows: according to Greece, international law and especially the UNCLOS resolution on CS gives the islands the right to exercise jurisdiction over their CS and specifies that the platform between two countries should be defined on the basis of the midline between the two States. Thus, each of the Aegean Sea islands has its CS and the borders with Turkey should be defined on the basis of that line. According to Turkey, the Greek islands do not have the right to exercise jurisdiction on the platform as they are located on the Turkish CS. In fact, the special circumstances mentioned by UNCLOS about the CS, as per its art. 6.2, justify, in this case, the non-application of the midline method.

Given the unsuccessful agreement, Greece submitted the dispute to the International Court of Justice (ICJ) in August 1976, but Turkey refused to recognize the jurisdiction of the court, which ultimately declared itself incompetent. The maritime issue has remained since then and has been aggravated by territorial disputes. International law, however, has evolved, affecting the position of the countries and increasing dissensions. According to Greece, UNCLOS represented a reinforcement in its understanding by specifying that coastal States could extend the area of their territorial waters to 12 NM, while, according to Turkey, the convention represented a strengthening of its understanding by removing any reference to the midline in the delimitation of the CS. In effect, as per the Convention, the delimitation of territorial waters, as well as of the EEZ, should be carried out by agreement, based on international law, in order to reach an equitable solution, pursuant to the prescriptions of Articles 74 and 83 of UNCLOS.

Turkey is one of the States that refused to sign the convention because it refused the possibility of extending the width of territorial waters to 12 NM. Therefore, the Convention cannot be applied to Turkey, in theory, but jurisprudence increasingly tends to consider that its main provisions, nevertheless, belong to international law. In this sense, the jurisprudence fills the UNCLOS gaps on the delimitation of maritime spaces. UNCLOS lacks methods for delimitation of maritime spaces, which has been progressively covered by the jurisprudence of the ICJ, which established applicable principles. Thus, that court defined the notions of equidistance, as well as special circumstances for the delimitation of the territorial sea and equitable principles for the continental shelf and the EEZ.

The Greek government, in 1987, began oil exploration near the island of Thasos, self-declared Greek but claimed by Turkey. In response, the Turkish government sent a research vessel escorted by warships to the same region. In an escalation of tensions, the Greek prime minister initially ordered the sinking of the Turkish research vessel, subsequently backtracking, which intensified the crisis between the two countries (STANICEK, 2020).

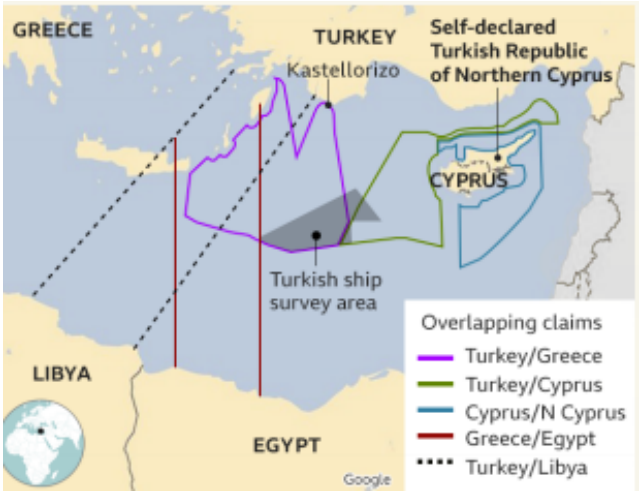
In the 1990s, tension increased. During the geopolitical issues of the Cold War (1947-1989), both, through NATO, aligned themselves against a common enemy and had, in a way, to leave disagreements in the background. After this phase, the two countries were able to dive

deeper into their individual interests and pursue their own goals, which rekindled tensions (MANN, 2001).

7 THE ENERGY ISSUE

After discovering the great potential for natural gas exploitation in the eastern Mediterranean Sea, relations in the region are being transformed and historical rivalries between Greece and Turkey are re-emerging amid geopolitical changes in the region. In July 2020, tensions between the two countries intensified due to Turkish oil and gas research activities in contested waters in the Eastern Mediterranean Sea, in an area of natural gas reserves recently discovered by Israel, Egypt and Cyprus, as shown in Figure 2. After the intervention of Germany, as EU representative, in order to mitigate the increased tension, both sides committed to dialogue for resolving the conflict.

Figure 2 – Map of the Maritime Dispute Area



Source: MARCUS, 2020

Energy security is increasingly an important factor in the strategy and geopolitics of States, seeking economic development and a prominent position on the international scene. However, in order to achieve better energy security conditions, actions to avoid the risk of energy shortages or to reduce the instability of lack of access to these sources may lead a State to apply strategic measures that go beyond diplomacy on certain occasions, being incisive in the international system so as to unilaterally achieve its objectives.

It should be noted that there are several divergences between Turks and Greeks regarding rights in the Aegean and Mediterranean Seas, which have intensified in recent years, mainly due to the Turks' high dependence on oil and gas imports, associated with recent discoveries of hydrocarbon reserves in the region, in addition to estimates of large undiscovered reserves (MARCUS, 2020).

According to Turkey, the final maritime borders can only be determined through agreements, not by violating possible third party borders, or through litigation. Thus, the country claims that it is ready to start maritime border delimitation negotiations with all neighboring countries except the Greek Cypriots. The demarcation in the west of the Cyprus island should take place after the most comprehensive solution of the Cyprus issue. The Turkish position is that the Cyprus island to the west and the Greek islands in the area, including Kastellorizo, cannot generate full EEZ/CS under international law, and the equal rights of Turkish Cypriots as co-owners of the island must be guaranteed immediately. Thus, Turkey will continue its research and drilling activities in the licensed areas of the Turkish Republic of Northern Cyprus unless the equal rights of Turkish Cypriots over *offshore* resources are guaranteed, as shown in Figure 2.

Additionally, the Turkish government has spread the concept of Blue Homeland (*Mavi Vatan* in Turkish). The term is an abbreviation of the Turkish claim that the 1920 Treaty of Sèvres, which ended hostilities between the Ottoman Empire and the Allied powers, unduly stripped Turkey of many of its historic islands and maritime possessions in the Aegean and Eastern Mediterranean seas[12] (RODRIGUEZ, 2020).

It is noted that Turkey has adopted an increasingly aggressive foreign policy in the Eastern Mediterranean sea, sending drillships accompanied by warships into waters claimed by Cyprus, which had already been leased by the Cypriot government to foreign oil companies. Such aggression towards its Mediterranean neighbours led to a deterioration of its relations with the EU, in particular with France, which despite showing its neorealist stance, runs the risk of Ankara isolating itself diplomatically.

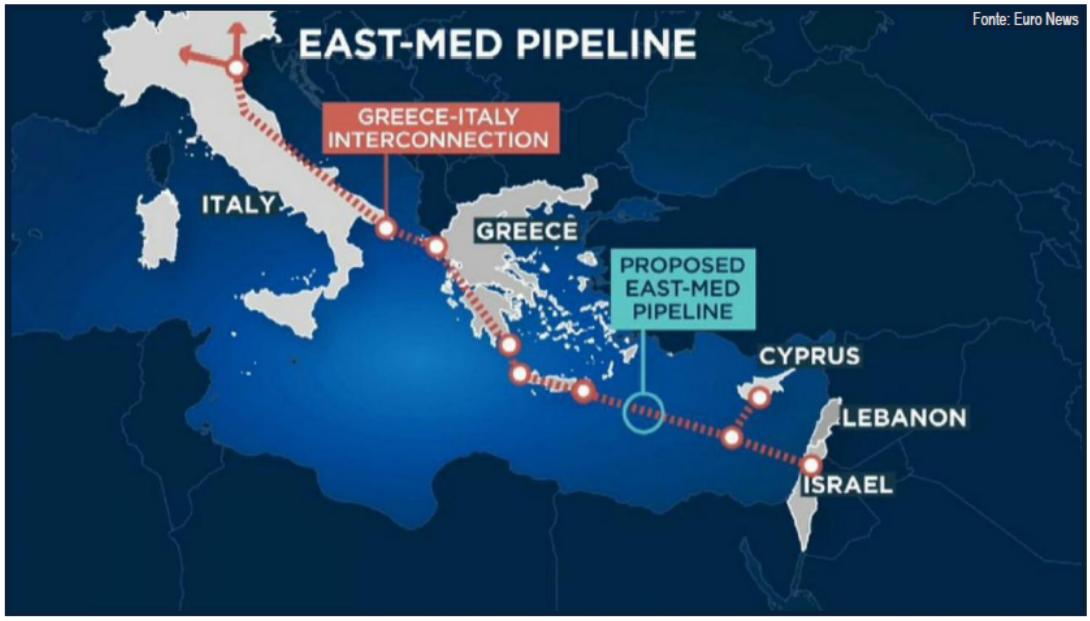
France has long been Greece's closest ally in Europe, sharing political values and cultural bonds. For its part, as a NATO and EU member country, France is prominent in the region with economic interests in Northern Africa, mainly through close relations with Greece, including joint military exercises in the Mediterranean Sea. Despite this close diplomatic relation of these two States and a distance from Turkey, which sees the EU as partial on the issue of maritime disputes, the influence – through economic power – of another European country, in this case, Germany, can also be observed. The German leadership in Europe is an important point in the geopolitical scene, since Berlin can play an active role in the crisis. In this regard, Germany has already played this role of European mediator in the disputes between Greece and Turkey, seeking to ensure EU interests and avoid an undesirable conflict between two NATO members (STANICEK, 2020).

The development of gas fields in the eastern Mediterranean Sea would be easier with Turkish cooperation. Israel, Cyprus and Egypt, however, are resisting Turkey's attempt to devote itself to developing these gas fields. In response, Turkey implied that it will block the *EastMed* pipeline construction project and that it may send military forces to do so (AUTRAN, 2021).

12 Restoring these possessions would allow Turkey to secure an additional 178,000 square miles of the Mediterranean Sea under Turkish control (RODRIGUEZ, 2020).

In January 2021, Greece, Cyprus and Israel signed an agreement to build an underwater gas pipeline that will transport large amounts of natural gas to Europe, in which Turkey is not a participant, according to Figure 3. In addition, Greece, Cyprus, Israel, Egypt, Italy, Jordan, the United Arab Emirates and the Palestinian Authority are united in the US-backed East Mediterranean Gas Forum (EMGF). For its part, Turkey, excluded from said forum, denounced it as an *anti-Turkish* club (AUTRAN, 2021).

Figure 3 – The *EastMed* project, connecting Eastern Mediterranean countries



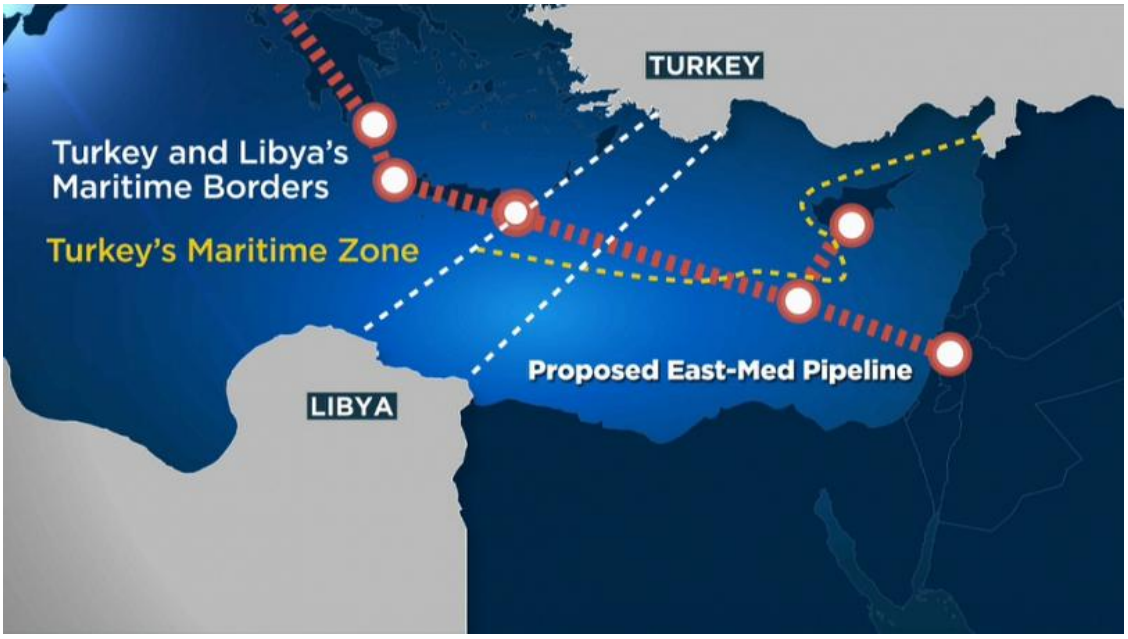
Source: AUTRAN, 2021

Turkey and Greece seek to meet energy needs through competition between their governments, aiming for lower external energy dependence on oil and gas. This situation can be observed through the recent discoveries of oil and gas in the eastern Mediterranean Sea, a fact that gave rise to a series of adverse events between the two States in search of meeting the demands of each country, taking into consideration the anarchic character of the international system.

In this context, the recent gas discoveries in the eastern Mediterranean Sea have served the strategy of increasing energy security, as evidenced by Turkey's policy towards Libya. In effect, two memoranda of understanding were signed with the Libyan Government of National Accord (GNA): the Delimitation of Maritime Jurisdiction Areas in the Mediterranean Sea and the Security and Military Cooperation Agreement (MARCUS, 2020).

The first agreement demarcated Turkey's maritime borders with Libya, with the bilateral creation of an EEZ extending from the Mediterranean coast of southern Turkey to the northeastern coast of Libya, disregarding the main Greek islands, such as Crete, as shown in Figure 4.

Figure 4 – Libyan-Turkish Maritime Agreement



Source: MENÉNDEZ, 2020

The second agreement enabled the GNA to resist Libyan National Army (LNA) leader Khalifa Hifter's offensive to take over Tripoli, as Turkey provided direct military support to the GNA. At a time when GNA's desperate requests for military support from European actors had no effect, the maritime border agreement was essentially the price to be paid to Turkey in exchange for military cooperation (MENENDEZ, 2020). Thus, the maritime border agreement was more related with the eastern Mediterranean Sea than with Libya. According to the resolution, the proposed Israel-Greece-Cyprus pipeline would have to pass through maritime areas claimed by Turkey, as per the Turkish-GNA maritime treaty, thus conveying Turkey's intention to halt any projects aimed at circumventing it.

However, as the agreements disregard important Greek islands, for example Crete and Rhodes, they are highly contested on the international sphere. For its part, Greece reacted forcefully, expelling the GNA ambassador from Athens and cultivating closer ties with the Libyan National Army (LNA), GNA's antagonist in the Libyan Civil War. Such attitude not only intensified the tension between Ankara and Athens, but also paved the way for Greece to sign a resolution with similar terms with Egypt in August 2020 to delimit their respective maritime jurisdictions.

The Turkish-Libyan agreement conflicts with the Greek view of its own maritime borders, while the Greek-Egyptian agreement produces the same effect with regard to Turkey. The connection between Turkey's policy in Libya as well as the strategic movements in the eastern Mediterranean Sea are expressed by the *Mavi Vatan* doctrine, or Turkish Blue Homeland, constituting Ankara's main geopolitical concept for the eastern Mediterranean Sea and establishing its neorealist stance.

In practice, it is possible to define the maritime agreement with Libya as a neorealistic strategic positioning. While this concept has no legal basis, it indicates Turkey's determination to defend and safeguard these projected borders, or at least try to confirm that impression. Secondly, the Blue Homeland is Turkey's call to project a possible repositioning of the country, representing the reorientation of Turkey's foreign and security policies in relation to Russia and China, which makes them a matter of national security for Greece, consequently affecting the EU.

8 FINAL CONSIDERATIONS

Kenneth Waltz's neorealism aims to understand the main causes of war in international relations through the analysis of three images: man, States and the State system. However, this has been the major influence in the case of wars, but which balances international relations between States, maintaining or negotiating peace.

The late twentieth century saw the rise of new international actors, which aim at cooperation between States in an anarchic international system, such as the UN and EU, making these relations more complex.

Turkey and Greece are NATO member States and pose a challenge to NATO planners, as differences must be taken into consideration in conducting training involving both countries. In addition, there was sometimes the risk of a war involving the belligerence of the two countries, which came very close to occurring in 1974, on the occasion of the Turkish invasion of Cyprus and, recently, on the occasion of the energy disputes in the Eastern South Sea.

The crises between Greece and Turkey are related to the process of formation of both States. In this sense, there are several examples, since the end of the Ottoman Empire, that unfold today through the situation of Cyprus and the maritime disputes. The differences between the two States were catalyzed by the recent discovery of energy resources in the Mediterranean Sea, which guarantee energy security and protagonism for these countries.

Greece is an EU member State, while Turkey is not. This difference has led to partnerships with other actors. Greece has been supported by France, which has affinities in the international system. Turkey clearly has a strategic pendulum movement, sometimes approaching the West, through partnership with the US and negotiations with the EU, sometimes approaching the East through bilateral partnerships and agreements with Russia.

This context of disputes has been aggravated by the recent discovery of energy resources that has motivated the disputes over Cyprus and the establishment of bilateral agreements between Greece and Egypt, or between Turkey and Libya, for divisions of maritime spaces in the international system.

For a peaceful solution to the current maritime dispute in the Mediterranean Sea, Greece and Turkey must be willing to establish an intermediate solution, which can be mediated by the EU or, more specifically, by Germany, whose foreign policy shows good relations with both States, in order to maintain the stability of relations of the countries bordering the Aegean Sea and the eastern Mediterranean Sea.

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Interagency Operation in question: notes about the MD33-M-12 manual (2017)

Operações Interagências em questão: notas sobre o manual MD33-M-12 (2017)

Abstract: Starting from a qualitative approach and using literature review and document analysis as a source for data collection, this article analyzes the 2nd edition of the manual for interagency operations, edited by the Brazilian Ministry of Defense in 2017, shortly after the major sporting events held in the country, when there was a possibility that the publication would incorporate the main teachings of the interagency work carried out in the period. This analysis made it possible to identify that this possibility was not confirmed, since the 2017 version is quite similar to the manual edited in 2012, including only minor changes in form, without showing noticeable evolution in doctrinal terms, with a planning methodology similar to that adopted by the Armed Forces. We identified a lack of a planning methodology specific to interagency operations, which imposes limits on the participation of agencies in the process, a leading role centered on the Armed Forces' performance in detriment of the participation of other agencies, and a military culture that makes it difficult for all agencies to participate in the planning stages. We argue that it is possible to use a more flexible and adaptive methodology on a larger scale in this type of operation carried out by other State agencies.

Keywords: interagency operations; interagency doctrine; planning methodology; ministry of defense; armed forces.

Resumo: Partindo de uma abordagem qualitativa e utilizando a revisão de literatura e a análise documental para coleta de dados e de fontes, este artigo analisa a segunda edição do manual *Operações Interagências*, MD33-M-12, editado pelo Ministério da Defesa brasileiro, em 2017, logo após os grandes eventos esportivos realizados no país, quando havia a possibilidade de que a publicação incorporasse os principais ensinamentos do trabalho interagências desenvolvido naquele período. Esta pesquisa identificou que essa possibilidade não se confirmou, pois a versão de 2017 é bastante similar ao manual editado em 2012, incluindo pequenas alterações formais, sem apresentar evolução perceptível em termos doutrinários, com uma metodologia de planejamento semelhante àquela adotada pelas Forças Armadas. Além disso, identificamos a falta de uma metodologia de planejamento própria das operações interagências, o que impõe limites à participação das agências no processo, um protagonismo centrado na atuação das Forças Armadas em detrimento da participação das demais agências e uma cultura militar que dificulta a inserção de todos os órgãos nas fases do planejamento. Argumentamos, portanto, que é possível a utilização de metodologia mais flexível e adaptativa no emprego, em larga escala, desse tipo de operação realizada pelas demais agências do Estado.

Palavras-chave: operações interagências; doutrina interagências; metodologia de planejamento; ministério da defesa; forças armadas.

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1 INTRODUCTION

When the Brazilian Ministry of Defense published the second edition of the manual for interagency operations, *MD33-M-12* (BRASIL, 2017), on August 30, 2017, there was a possibility that this review, originally edited in 2012 (BRASIL, 2012), would include some advances in methodological terms (BRASIL, 2016b)[1], which would allow interagency agreements that are more flexible and adaptable to various situations, including their use in operations in which the coordination is exercised by an agency other than the Armed Forces (FIGUEIREDO; MOREIRA; CAMINHA, 2023).

Given that in the four years prior to the publication of the manual (2013-2016), state agencies had undergone experiences that required a large investment in interagency operations to deal with the challenges of public security in the preparation and execution of these movements during major sporting events[2] held in the country (REVISTA DA ASSOCIAÇÃO NACIONAL DOS DELEGADOS DE POLÍCIA FEDERAL, 2017), which provided "a kind of laboratory, in which civil and military actors could interact, sharing experiences and better understanding other's culture" (CABRAL, 2019, p. 43; our translation).

Additionally, the works developed both by interagency operators, such as Rosa (2015) and Cabral (2019), and by theorists, such as Araujo Neto (2017) and Vasconcelos (2018) have pointed toward the need to take advantage of the knowledge acquired when Brazil hosted the major sporting events, as well as to improve the doctrine for planning and executing operations of this nature. According to Rosa, when dealing with the lessons learned after the 2014 World Cup:

> The Ministry of Defense acted effectively, with **opportunities for improvement in the field of doctrines**, behaviors, and procedures to be implemented. The coordination and purposes unit; the establishment and execution of a matrix of interagency responsibilities and protocols; **the development of Interagency doctrine**; and greater integration and complementarity in actions are the main opportunities for improvement in the Interagency environment. (ROSA, 2015, p. 48, our translation, emphasis added)

In the wake of this discussion, Araujo Neto addressed the doctrinal issue by signaling that:

> There should be a reference doctrine, breadth in personnel training, rigorous training, and focused evaluation. In fact, the results of the evaluations should

1 In an interview with the Brazilian Air Force Portal, during the seminar on lessons learned at the Rio 2016 Olympic and Paralympic Games, held in Brasilia in October 2016; Aviator Colonel Luiz Cláudio Magalhães Bastos, from the Special Advisory Service for Major Events (AEGE), from the Brazilian Ministry of Defense, stated that: "the consolidation of [seminar] work will generate a report, which will serve as a beacon for [the Armed Force's] future actions" (BRASIL, 2016b, our addition).

2 According to Meurer and Lins (2016), sporting events that are considered major include: the 2007 Pan American Games; the 2013 Confederations Cup; the 2014 FIFA World Cup; and the 2016 Olympic Games.

> feed back into the system for the refinement of the doctrine, repeating this cycle over time. (ARAUJO NETO, 2017, p. 36)

Advancing in this debate, Vasconcelos (2018) drew a comparative picture—in terms of interagency work—between the major events held in Brazil and the attack of September 11, 2001, in the United States of America (USA). For the author, in both cases it was necessary to create integrated systems in order to provide responses to threats to public safety.

Considering this contribution, we can infer that the Confederations Cup (2013) and the FIFA World Cup (2014), in addition to the Rio 2016 Olympic Games, could have done a little more, such as the attack on U.S. soil, to better ground the doctrinal-methodological framework in carrying out interagency operations in the country.

The theme is also discussed in the investigative work conducted by Cabral (2019), in which, when interviewing several interagency operators[3] who worked in the Rio 2016 Olympic Games; he demonstrated that, despite all the effort undertaken, the learning obtained during the event ended up not being used in its entirety.

Nevertheless, the desire of theorists and interagency operators for the lessons learned in the period to be in fact incorporated into the doctrine, thus generating methodological improvement, were frustrated. This is because the publication of the new MD33-M-12 (BRASIL, 2017) included only minor changes in terms of form, without presenting perceptible evolution in doctrinal terms, being practically the same as the previous version (BRASIL, 2012), whose planning methodology was basically that adopted by the Navy, Army, and Air Force in their joint planning[4].

It is within this context that this article's objective, which aims toward an analysis of the second edition of the manual for interagency operations (*Operações Interagênciais,* BRASIL, 2017)*,* is configured*,* pointing out potential obstacles to its use in a more comprehensive way, especially when dealing with joint operations, that is, with the participation of other organs, in addition to the Armed Forces. With the help of this analysis, we argue that it is possible to use a more flexible and adaptive methodology in the large-scale use of interagency operations carried out by other agencies of the Brazilian State.

2 METHODOLOGY

Given the nature of its object, this article adopted a qualitative methodological approach. The production of data for the research occurs in two procedures: (1) literature review; and (2) document analysis. The literature review investments sought analyses that framed the phenomenon herein discussed in two distinct scales: national and international, seeking to synthesize productions about the existing theme. Inspired by the methodological

3 Cabral (2019) interviewed public agents who held positions of leadership or command in the planning of their respective security agency during the preparation and execution of the Rio 2016 Games.

4 The joint planning process is detailed in another Defense Ministry publication called *Joint Operations Doctrine*, MD-30-M-01, volume 1 (BRASIL, 2020a) and volume 2 (BRASIL, 2020b).

steps recommended by the Joanna Briggs Institute (JBI), the research question was determined; relevant studies were identified; articles that addressed interagency operations in major events in the period from 2013 to 2016 were selected; data was collected; and the results were summarized (PETERS *et al*., 2020). Regarding the documental analysis, the study focused mainly on the normative framework that deals directly or indirectly with interagency operations within the Brazilian State. In this sense, manuals that deal with the doctrine of this type of operation, manuals about joint operations, as well as decrees and ordinances, were analyzed.

3 CONTEXTUALIZING MD33-M-12 INTERAGENCY OPERATIONS (2017)

Divided into three chapters and two annexes, just like the previous version, the 2017 edition has 72 pages (BRASIL, 2017), while the first edition has 46 pages (BRASIL, 2012). The 26-page difference, which in principle would indicate a substantial theoretical addition to the manual, is composed solely of the expansion of the interagency glossary, located in the final part of the publication.

The importance of the search for a common lexicon, partially met by this glossary, is not disputed, because, according to Carafano (2011), Field (2021), Ferreira (2022), and Figueiredo and Moreira (2022), the improvement of the understanding between agencies seeks to achieve one of the basic aspects for the success of interagency work. In this sense, the expansion of the glossary in relation to the 2012 edition (BRASIL, 2012) is an appreciable evolution to be noted.

Therefore, when opening the manual, the lack of clarity as to the degree of participation of the agencies in the process of planning operations can be noticed. This is already noticeable in the introduction, where its purpose is presented:

> Establishing the doctrinal foundations that will guide the Armed Forces in the process of planning, preparing, and employing joint operations (Op Cj) **involving** the participation of public agencies, non-governmental organizations, private companies, or agencies of other Powers, **in the execution of actions**. (BRASIL, 2017, p. 13; our translation, emphasis added)

The two fragments in bold can generate an understanding of limited participation of the other agencies, restricted only to the execution of actions, neglecting the planning phase of interagency operations, under the coordination of the Armed Forces. This is because interagency relations carry in their concept an idea of balance of power and participatory decision-making that is only possible if there is the commitment of all participating agencies, and not just mere involvement (ANSELL; GASH, 2007; FERREIRA, 2022; JOHNSON *et al*., 2003).

The fact that the publication of the MD33-M-12 (BRASIL, 2017) remains as a doctrinal manual without its own usage methodology, same as the 2012 edition, is also seen as a possible problem.

A neophyte interagency operator, who is dedicated to reading the manual on screen for the first time, and who is looking for a methodology to help them plan an operation,

will not find it there, since it is not included in the interagency manual. It is necessary to be aware of the five citations contained in the text, alluding to another publication of the Brazilian Ministry of Defense (MoD), entitled "Doctrine of Joint Operations" (*Doutrina de Operações Conjuntas*), MD30-M-01. Of the five citations found in the MD33-M-12, we understand that the most relevant is the one in chapter III, item 3.1.4, which discusses interagency planning:

> [the] planning follows the provisions of the publication MD30-M-01, with the necessary adaptations, maintaining the specific attributions and competencies, at the different levels of decision, with the elaboration of the corresponding planning documents. (BRASIL, 2017, p. 23, our addition)

In other words, it is described that the methodological basis is that provided by MD30-M-01, the Joint Operations Doctrine, specifically in its second volume, adapted to a reality in which the agencies participate in the operation.

It is understandable that the interagency manual has used the already consolidated doctrine of joint operations as a planning methodology, of which the use is specifically focused on operations with participation in the Armed Forces, after all, it was gestated and published by the MD. Item 1.4 evidences this application:

> The doctrine established in this publication applies to the Commands provided for in the Military Defense Structure and directs the joint employment of the Armed Forces, and must be observed at all levels of planning and execution. (BRASIL, 2017, p. 14; our translation)

The issue that arises is that, in the absence of another methodology for planning interagency operations in the country, this manual has been used by other bodies and agencies, such as the Fire Department of the State of Mato Grosso Sul (MATO GROSSO DO SUL, 2018). In this sense, the intrinsically military approach hinders both the use of the methodology by other agencies in operations without the participation of the military, and the incorporation of the agencies into the planning of an operation under the coordination of the Armed Forces.

We believe the analysis made by Araujo Neto (2017) about the 2012 version of the manual proved to be quite appropriate when highlighting that:

> the biggest problem of the Brazilian document [...] [it's] its **purpose geared toward military** professionals only. That is, considering only the military's organizational peculiarities and operational norms, ignoring the existence of the others, as if all other organs were uniform in non-military procedures and norms. In this way, the document becomes inflexible, shutting down any opportunity for its concepts to be absorbed by other parts of the federal public administration. (ARAUJO NETO, 2017, p. 24; our translation with our emphasis and additions)

Despite the review carried out in 2017, these considerations remain valid when we observe that the publication starts from an even more assertive premise than that of the 2012 publication, regarding the preponderance of the Armed Forces, as identified in the citations:

> When the State decides to carry out an action, applying force to assert its interests within [...] its territory, **the Armed Forces form the preponderant component in relation to the other available instruments**. (BRASIL, 2017; our translation, emphasis added)
>
> When the State decides to carry out an action, applying force to assert its interests within [...] its territory, the Armed Forces **generally form the preponderant component in relation to the other available instruments**. (BRASIL, 2012; our translation, emphasis added)

From the above, it becomes clear that the 2017 publication was designed to be used in situations in which the Armed Forces take a leading role in relation to other agencies, which only perform tasks to support the military. This logic permeates the entire manual since the agencies present only the *status* of friendly forces[5] for the planning and execution of the operation.

As a consequence of this process, we point out that the military predominance may generate coordination difficulties during the operation due to the limitations for the performance of civilian agencies, which may compromise solutions, or at least the management of the problems for which the interagency working group was constituted. Thus, according to Figueiredo and Moreira (2022), poor coordination can create obstacles to the success of the operation. Such aspects will be further explored in the following topics.

4 CONTRIBUTIONS TO THE ANALYSIS OF THE MD33-M-12, *INTERAGENCY OPERATIONS* (2017)

4.1 Lack of a methodology for interagency planning

If, on the one hand, it can be said that the methodology of the joint planning process of the Armed Forces is well structured to face the "current military problems" (MOREIRA, 2022, p. 22; our translation)—by incorporating several modern tools in the recent edition of the two volumes of the *Doctrine of Joint Operations* manual (BRASIL, 2020a, 2020b)—the same cannot be said regarding the interagency doctrine.

The lack of a methodology for a genuine interagency planning process, which allows other agencies to participate fully in the planning and execution of the operation may bring negative implications to the effectiveness of interagency work, if any participating agency perceives that its perspective and interests are being marginalized throughout the process.

5 According to the Armed Forces' Glossary, Friendly Force is defined as: "A Force that, not being in the chain of command of the commander, performs a task that contributes to the fulfillment of its mission"(BRASIL, 2015, p. 120). The description of which agencies will take part in the operation should be part of item 2.4 of the Operational Situation Examination Model, contained in Annex A of the MD33-M-12 (BRASIL, 2017, p. 34).

Moreover, if participation in interagency arrangements is voluntary, the planning and execution methodology should be attractive to all participants. However, this is not what appears in the wording of the MD30-M-01 (BRASIL, 2020b). The joint doctrine was developed by the military to be used by the military, and its simple adaptation to incorporate civilian agencies into the planning process is inadequate, especially since it limits the participation of other agencies in the operation.

4.2 Limits on the participation of agencies

Agencies cannot be merely consulted about the decisions being made throughout the planning. They must actively participate from the beginning of the plans' elaboration, acting in the correct definition and framing of the problem that to be faced. Such commitment generates equal responsibility regarding the results since the opinion and interest of all agency representatives were considered in structuring the response to solve, or manage, the problem. And, at this point, the manual is erroneous in segregating the lines of action[6]—to be carried out by the Armed Forces—from the activities performed by the other agencies, which can impact the coordination of the operation as a whole. This quote illustrates this separation:

> [...] the Operational Commander [...] identifies the particular objectives of each agency and coordinates actions, through the following steps: [...]. **Defining the lines of action for the area of military operations and coordinate them with the activities of the agencies** [...]. (BRASIL, 2017, p. 24; our translation, emphasis added)

The interagency coordination is discussed by Ansell and Gash (2007), when they associate this type of arrangement to a collaborative governance. According to the authors, a critical component that characterizes interagency work is the fact that it is a formal process of collective decision-making. In other words, the participants are not merely consulted, but there is a direct performance and commitment of them at all stages of the decision-making process. Collective decision-making implies that it is not an individual deciding alone, but rather groups of individuals, organizations, or organization systems. Agencies must be present at all stages and phases of the actions' planning and execution, in a deliberative and multilateral process that allows two-way communication flows.

4.3 Decision-making forums with limited assignments

To circumvent this difficulty, the MD33-M-12 (BRASIL, 2017) provides some forums for agencies to participate within the structure of the General Staff[7], namely: Oper-

6 Possible solution that can be adopted for the fulfillment of a mission or execution of a job (BRASIL, 2017, p. 58).

7 According to the Armed Forces' Glossary, General Staff is: "Organ composed of qualified military personnel, whose purpose is to advise the commander in the exercise of command" (BRASIL, 2015, p. 108; our translation).

ations Coordination Center (CCOp)[8], Humanitarian Operations Center (COH)[9], and Civil-Military Coordination Center (C^2M)[10]. However, these decision-making spaces have limits in their attributions. For, although the agencies take part in such bodies, they do not organically compose the sections[11] of the General Staff, constituted to deal with interagency problems. Therefore, they have a limited role in the planning of the operation, performing, almost always, specific and punctual tasks deliberated by these forums, but endorsed by the military commander of the operation. Thus, regardless of the centers' (CCOp, COH or C^2M) format, they are unable to provide an effective participation of the agencies in all phases of the planning and execution of operations.

4.4 Leading role centered on the Armed Forces

In addition, despite the intention of providing consensus[12], such forums also do not account for the necessary division of protagonism within an interagency operation that uses the methodology in question, since the preponderance is always military. Which, in itself, is also a problematic consideration, especially when the search for protagonism overlaps the achievement of common goals. In this regard, Araújo Neto indicates that:

> The predominance of the search for protagonism in institutional relations makes the actions of each public agency compartmentalized, which may hinder the development of legal attributions and the achievement of each agency's social objectives [...]. Public agencies would need to find interesting or really necessary reasons for them to decide to pursue common goals with other institutions in detriment of the traditional search for performance results or the strengthening of their media protagonism. (ARAUJO NETO, 2017, p. 10; our translation)

These issues of dispute for coordination and protagonism would have already created difficulties and obstacles to interagency work involving the participation of the

8 "Integrated by representatives of each involved agency [...], it will detail the planning and trigger the actions necessary to fulfill the mission based on the documents received" (BRASIL, 2017, p. 23; our translation).

9 "[...] COH members coordinate the general relief strategy, identify logistical needs for agencies, and identify and prioritize humanitarian assistance needs for military support" (BRASIL, 2017, p. 29; our translation).

10 "The operational commander may constitute a C^2M to: – advise him on guidelines and decisions related to civil-military coordination; – liaise and coordinate between Military Forces and agencies so that they meet the needs of the population; – establish a participatory forum for military and civilian organizations; and – receive, validate and coordinate requests for support from non-governmental organizations, private companies and international organizations" (BRASIL, 2017, p. 28; our translation).

11 The first volume of the Joint Operations Doctrine defines the composition of the Joint Chiefs of Staff (EMCj) and its sections: "The EMCj shall consist of the Chief of Staff and, in principle, the following sections: a) D-1: 1st Section (Personal); (b) D-2: 2nd Section (Intelligence); (c) D-3: 3rd Section (Operations); (d) D-4: 4th Section (Logistics and Mobilization); (e) D-5: 5th Section (Planning); (f) D-6: 6th Section (Command and Control); (g) D-7: 7th Section (Social Communication); (h) D-8: 8th Section (Information Operations); (i) D-9: 9th Section (Civil Affairs); and (j) D-10: 10th Section (Financial Management)" (BRASIL, 2020a, p. 51).

12 Consensus, according to the manual, would be one of the guiding principles of interagency operations, alongside collaboration; ability; knowledge; prioritization; unity of effort; flexibility; objectivity and integration (BRASIL, 2017).

military in operations under the coordination of other agencies. The example of *Operação Brumadinho* (2019) (MINAS GERAIS, 2022) is very characteristic, when help from the Armed Forces to act in the operation was partially refused by the Government of the State of Minas Gerais. The quotes below illustrate the situation:

> The work protagonism division in the aid of the victims of the Brumadinho tragedy has caused several 'short circuits' between the government of Minas Gerais and the Armed Forces. These deployed a contingent of a thousand men since Friday to assist in rescuing survivors. Except that there was no request to use the group. The Minas Gerais government reported that there was no need for this type of support and, if it needed it, it would request it. (PARREIRAS, 2019; our translation)
>
> 'Strangeness' and 'frustration' were the feelings among military members of the Armed Forces who have been on standby since Friday, the 25th, in Belo Horizonte, waiting to assist, at first, in helping to try to rescue people who could be in isolated areas or in the mud, because of the rupture of the Dam in Brumadinho – and, then, to assist in the rescue of bodies, in an attempt to reduce the suffering of those who are in search of their relatives. (ESTADÃO CONTEÚDO, 2019; our translation, emphasis added)

During the operation, the participation of the Brazilian Armed Forces was punctual and with an estimated total of only 190 military personnel (BRASIL, 2021), a minute contingent compared to the over four thousand people who worked in the region (FREITAS, 2021). The number of Brazilian military personnel was similar to that of Israeli military personnel[13], who took part in the search for missing persons (PARREIRAS, 2019).

The quarrel that occurred in Minas Gerais is not an isolated fact. The search for protagonism and the difficulty of coordination are also present in operations whose coordination is under the aegis of the Armed Forces, such as *Operação Acolhida*, which began in 2018 and is considered, according to Costa (2020), a case of success in terms of interagency relations.

Despite the acknowledged success, there were some problems:

> *Operação Acolhida* has a horizontal governance structure, in which there is no subordination between the actors. Despite this, through the fieldwork it was possible to observe that there are actors with greater protagonism and that consequently influence the actions of the other actors. (COSTA, 2020, p. 43; our translation)
>
> civil and military cooperation in *Operação Acolhida* needs to be adjusted, so that those organizations that feel less represented are encouraged to take a more active role and have their value recognized. Reports have shown that these agencies consciously avoid attending meetings when there is no space to address their specific demands. There were also reports of disagreements between civilian and military representatives [...]. (COSTA, 2020, p. 80)

13 136 Israeli military personnel participated in the Brumadinho operation (PARREIRAS, 2019).

Costa's citations (2020) illustrate difficulties of interagency work, which could be minimized with greater participation of civilian agencies from the beginning of the planning.

5 THE MILITARY CULTURE

Finally, the last point considered relevant is the appreciation that the military has for the principles of war[14] of the command unit, which is "held in high regard by soldiers" (VISACRO, 2017, p. 98), who are not so willing to renounce it. In this sense, imagining a coordination in charge of another agency in an interagency operation with the participation of the Armed Forces would be culturally unlikely. Obviously, the methodology provided for in the MD30-M-01 (BRASIL, 2020b) indicates this predisposition to command by the military establishment. It is worth noting that acting in external conflicts is usually the most important role of the Armed Forces. And in this sense, traditional military operations require trained professionals and large operational units, which are conducted by combatants with high-tech weapons in an environment whose individuals involved in the conflict are potential targets.

However, non-traditional missions place soldiers in situations where targets are mixed with those they must protected. In addition, non-traditional operations, such as interagency operations, are generally conducted in a decentralized manner, combining not only military personnel from different forces, but also involving federal agencies, police, local leaders, non-governmental organizations, among others. This characteristic tends to confuse military members that are accustomed to submitting to well-defined lines of command.

The incompatibility between the characteristics that make up the traditional and non-traditional models ends up causing the imposition of military models informing and guiding interventions in this type of operation, which tends to cause conflict, on many occasions, between military personnel and technical staff of institutions with expertise in the area, as in the case assisted in Operations Verde Brasil I and II[15]: "The military does not like interference in command, such as technical guidelines, to achieve better results. Any observation is seen as a bottom-up order, from inspector to military," said a technician from the Environmental Development Secretariat (Sedam) of Rondônia in the report: Deforestation combat is harshly criticized by defenders of the Amazon, of July 28, 2020 (OLIVEIRA, 2020).

14 The definition of War Principles, according to the Glossary of the Armed Forces (BRASIL, 2015, p. 223; our translation) is as follows: "Philosophical precepts arising from military campaign studies throughout history and present variations in space and time. They are reference points that guide and subsidize the military leaders in the planning and execution of war without, however, conditioning their decisions. The commander, when planning and executing a campaign or operation, will take into account what the principles recommend, interpreting them and applying them judiciously in the face of the situation, deciding which ones he will privilege, in detriment of others."

15 *Operação Verde Brasil* was a set of activities triggered by the Federal Government, after the authorization of the use of the Armed Forces in the Guarantee of Law and Order (GLO) in subsidiary actions in the border strip, indigenous lands, federal units of environmental conservation and other federal areas in the states of the Legal Amazon, through preventive and repressive actions against environmental crimes, aimed to combat illegal deforestation and fire outbreaks (BRASIL, 2019). The first edition of this operation, instituted by Decree No. 9,985 of August 23, 2019, initially took place between August 24 and September 24, 2019, and was subsequently prolonged for 30 days, extending until the end of October. In 2020, the second edition of this operation took place through Decree No. 10.341, of May 6, 2020, in which the government instituted *Operação Verde-Brasil 2* for the prevention and repression of illegal activities and fires in the Amazon region (BRASIL, 2020c). This edition, initially scheduled for 30 days, was extended to 60 days (amendment given by Decree No. 10.394, of June 10, 2020), starting on May 11 and extending until July 10, 2020 (BRASIL, 2020d). In turn, Decree No. 10.421, of July 9, 2020, extended the employment of the Armed Forces until November 6, 2020 (BRASIL, 2020e).

This observation is worrisome, since the demand for the use of the Armed Forces in interagency operations, acting jointly with other agencies of the Brazilian State, has become frequent (MOREIRA, 2018) and tends to intensify due to the range of complex problems to be faced by the Brazilian authorities, such as transnational crimes, environmental disasters, epidemics, migration crises, etc. (FIGUEIREDO; MOREIRA, 2022).

6 CONCLUSIONS

This article infers that a possible solution to reduce such tensions, in addition to the forums already foreseen (CCOp, COH and C²M), would be the effective incorporation of the agencies into the sections of the General Staff constituted for the planning of the operation. Thus, a more flexible planning methodology could foresee such a possibility. Moreover, the unity of efforts, and not the unity of command, must be seen as an integrated work in favor of a synergistic approach, which should not become a hierarchical organization, under penalty of not having the adhesion of the agencies.

That said, the simple coordination of the activities in which each agency performs its tasks individually and in parallel is not enough. An interdependence of actions and a complementarity of resources should be sought. This is only possible with the identification of collective common goals that lead to mutual benefits.

As for the synergy of actions, Thomson and Perry describe that "the whole is greater than the sum of its parts" (2006, p. 23). The result of the integrated work should be greater than the simple sum of the actions carried out individually by each agency. Thus, the manual should promote the broad and active participation of agencies in all stages and phases of the process of planning and execution of actions.

Nevertheless, the issue of coordination by another agency, other than the Armed Forces, still encounters strong resistance in the barracks since the principle of unity of command is a cultural aspect difficult to overcome by the military due to it is constitutive character in the institutional *habitus*.

The possible solution envisaged would be the production of an interagency doctrine by other bodies, which coordinate interagency work at the most diverse levels, such as the Institutional Security Bureau (*Gabinete de Segurança* Institucional – GSI) of the Presidency of the Republic, coordinator of the Executive Committee of the Integrated Border Protection Program[16] (*Comitê Executivo do Programa de Proteção Integrada de Fronteiras* – CEPPIF), via the National Defense and Security Affairs Secretariat (*Secretária de Assuntos de Defesa e Segurança Nacional* – SADSN). Thus, we would have other interagency doctrines, in addition to the manuals produced by the Armed Forces.

Lastly, we defend the relevance of the development of research and studies along these lines, both for its contribution to the debate and studies of interagency relations and for the possibility of offering improvements in the way agencies act mutually. To the extent that such knowledge can provide new perspectives on the issue, deepening and complexifying it, especially when analyzed from the point of view of promoting Brazil's defense capacity.

16 The Integrated Border Protection Program was established by Decree No. 8.903 of November 16, 2016 (BRASIL, 2016a).

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