Article

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Broadening the vision of the Mechanized Cavalry Platoon: the remotely piloted aircraft system

Ampliación de la visión del Pelotón de Caballería Mecanizado: el Sistema Aéreo Remotamente Pilotado

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Abstract: The paper proposes to contribute to the debate about the use of the Remotely Piloted Aircraft System (RPAS) as an auxiliary tool, expanding the results of the reconnaissance operations of the Mechanized Cavalry Platoon. Thus, based on an approach that considers the definitions, the relevant legislation and the characterization of use, it seeks to contextualize its operational application, concluding with the suggestion of a way for the systematic and standardized use of RPAS, also connecting some basic logistical aspects.

Keywords: Drones. Unmanned Aerial Vehicles. Remotely Piloted Aircraft System. Mechanized Cavalry Platoon.

Resumen: El presente artículo se propone a contribuir al debate acerca del empleo del Sistema Aéreo Remotamente Pilotado (SARP) como herramienta auxiliar, expandiendo los resultados de las operaciones de reconocimiento del Pelotón de Caballería Mecanizado. Así, desde un abordaje que considera las definiciones, la legislación pertinente y la caracterización de uso, se trata de contextualizar su aplicación operativa, y se concluye con la sugerencia de un camino para el uso sistemático y estandarizado del SARP, conectando también algunos aspectos logísticos básicos.

Palabras clave: Drones. Vehículos Aéreos No Tripulados. Sistema Aéreo Remotamente Pilotado. Pelotón de Caballería Mecanizado.

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1 Introduction

The aim of this article is to contribute to the studies on the Remotely Piloted Aircraft System (RPAS), suggesting a viable path for its systematic incorporation, more specifically into the recognition function of the Brazilian Army (BA) Mechanized Cavalry Platoon (Pel C Mec). It is not intended to "reinvent the wheel", but to present data that can reinforce discussion, analysis and consequent decisions, based on the documents "Bases for the Transformation of Terrestrial Military Doctrine"[1] (BRASIL, 2013, our translation), from the Army Special Bulletin No. 28/2014 (bee 28-14) (BRASIL, 2014a)[2] and the "Development Plan of the Terrestrial Military Doctrine 2016/2017"[3], in its Annex "E", which addresses the "Essential Elements of Doctrinal Information" (BRASIL, 2015, p. 24, our translation).

Bee 28-14 (BRASIL, 2014a) shows the operational allocation of RPAS to surveillance activities (Activity 1.2.4.3: "Continue to distribute RPAS and Ground Surveillance Radars for the modernization of the 4th Bda C Mec"), as part of the SISFRON/Sentinela da Pátria projects from the program Obtenção da Capacidade Operacional Plena (OCOP – Full Operational Capacity Achievement). This document was also a motivational aspect for the research on the option of utilization targeting of the RPAS by the Pel C Mec.

In addition to obtaining the different information and field verifications, the relevance of the study is supported by its scope, since it not only considers the operational issue, but also connects management/organizational and logistical aspects.

In this sense, and based on the synthetic understanding of AKVA (Sanskrit word meaning position superiority during combat, obtaining advantage or fighting in position advantage — origin of the term "Cavalaria", or Cavalry, in Portuguese), the article is anchored in primary recognition function of the Pel C Mec according to the parameters that guide it.

"Gaining advantage in combat" follows the logic that recognition must present as a product specific and relevant information (about the terrain and the opposing force) that leads to decision-making by the superior command. Obviously, the combat in advantageous position must be the consequence of the decisions taken.

Bibliographic and documentary searches (literature, manuals, applicable legislation and other specific documents), online surveys, field surveys (with visits and personal interviews at manufacturing companies and operating units — not just in the Army), as well as observation and interviews with Cavalry type military (and others involved in reconnaissance missions) are the basic components of the methodology used.

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1 Approved by Ordinance No. 197-EME of September 26, 2013, it is intended to "guide the introduction of doctrinal conceptions and concepts aiming at incorporating into the Earth Force the skills and competencies required for its use in the Knowledge Age." (our translation) This approach replaces the planning conception model based simply on an "Employment Hypothesis." Referring to required competencies, it cites Geoinformation and Remotely Piloted Aircraft Systems as examples of systems that significantly alter military capabilities.

2 Approved by Ordinance No. 1.507 of the Army General Secretariat (Army Strategic Plan 2016-2019, part of the Army Planning System).

3 Approved by Ordinance No. 339-EME of December 17, 2015, it guides the planning and coordinates the implementation of actions related to the production of the Terrestrial Military Doctrine, in the 2016/2017 biennium. See details in Chart 3, p. 15 of this article.

To achieve the proposed objective, the article uses as a "guiding thread" a brief passage on the genesis of unmanned aerial vehicles (UAVs), their general characterization, explanations regarding existing nomenclatures and a brief visit to the applicable legislation in Brazil, distributed according to the protagonism of the various organisms involved. It then discusses the current use of this equipment by our Armed Forces, contextualizing Pel C Mec's operational mission and the use of RPAS. It establishes basic considerations on some logistical aspects, such as the acquisition and maintenance of equipment and the necessary training. It concludes with the presentation of a proposal — considering an optimal model — for the operational structuring of the RPAS, which lists the main necessary activities, prioritized through a simple management support tool (GUT Matrix).

2 Probable Genesis And Evolution

Although the use of UAVs seems to be a recent subject, its application dates back to the 19th century, when Austrians loaded unmanned balloons with explosives to attack targets in Venice (UBIRATAN, 2015, p. 12). Even before World War I, people studied ways of sending explosive artifacts through the air to targets tens of kilometers apart, which is now accepted as the embryo for missile creation.

However, the first UAV, as it is now known, appeared in 1951, when the Ryan Aeronautical Company went on to develop the Firebe, a jet UAV intended to serve as an air target launched from an airplane. Following development, a new generation used a computer control system. It could also be launched from the ground, through a catapult.

But it was in the Second Gulf War, which began in 2003, that they became better known to the general public, as they were widely used by US forces for enemy monitoring, targeting, and even launching guided weapons (PECHARROMÁN; VEIGA, 2017, p. 7).

These aircraft are currently at the cutting edge of the latest technology, being used in the most varied activities, such as precision agriculture, generation of photos and images in general, whether for civil use, defense or security.

As seen, drones[4] have been used for a long time around the world and their applications are increasingly innovating. In Brazil, mainly from the regulation of its use, the market has seen great growth. According to Granemann (2018), the country already has more than 700 companies, among which — according to Pecharromán and Veiga (2017) — 15 manufacturers have already been identified[5].

4 Also known as UAV (Unmanned Aerial Vehicles).

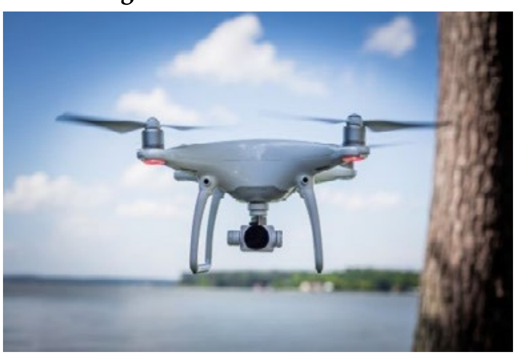
5 AEL Sistemas, AGX Tecnologia Ltda, ARPAC (ex-Agrone), AVIBRAS, Avionics Services, BRVant, Brasil Aircrafts, FT Sistemas S/A, Gyrofly Innovations, Santos Lab Com. and Ind. Aerospace Ltda, Sensormap, SkyDrones and XMobots. See more information at Pecharromán and Veiga (2017).

3 Characterization and nomenclatures

In order to facilitate the contextualization of the theme, it follows the characterization of the various terminologies used for the designation of unmanned aerial vehicles, according to ANAC (2017a, 2017c), Você... (2017) and Gomes (2016).

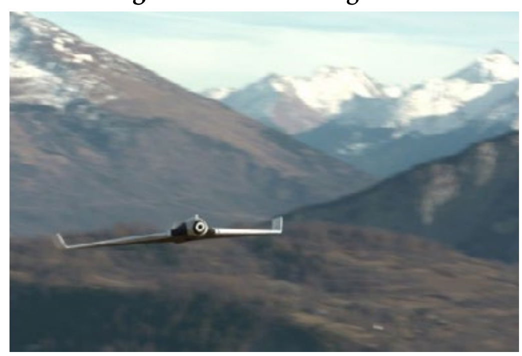
UAV – is a terminology used to define the scope of the activity. UAVs are aircrafts designed to operate without a pilot on board. However, in order to live up to this terminology, the aircraft must not have a recreational character, besides needing to have payload (cameras, sensors, etc.) on board. UAVs can be classified as multi-rotor and fixed wing (Figures 1-1 and 1-2).

Figure 1-1 - multi-rotor UAV



Source: Gomes (2016).

Figure 1-2 - fixed wing UAV



Source: Gomes (2016).

The multi-rotor UAVs are the best known and most used models in the world, especially the quadcopter. They use the same flight principle of helicopters, through rotor wings, which have high RPMs, which allows the flight. Multi-rotor UAVs have limitations on spcΩeed, endurance and range (BOON; DRIJFHOUT; TESFAMICHAEL, 2017; CHAPMAN, 2016). However, they are easier to control, can be static in the air and take pictures and record videos of fixed points or smaller areas. Commonly used batteries allow the model a range of 20 to 30 minutes, although there are already multi-rotors with more modern systems that use battery plus combustion generator, which offer more than two hours.

Fixed wing UAVs are completely different from the multi-rotor model and are very similar to airplanes. They usually have a delta wing, which creates lift for flight, and a propeller-like engine at the rear that propels it forward. Because they only need power to propel them forward rather than hold them in the air — as in the case of the multi-rotor model — they are much more efficient. They can cover large distances and wide areas by monitoring various points of interest. They have a considerably longer range compared to the multi-rotor model. The fixed wing model is widely used in military operations for reconnaissance, considering its higher energy efficiency, maneuverability and speed. Through the use of high-resolution sensors and cameras, fixed wing UAVs have allowed great advances in many areas. Further details of the differences between both models are shown in Table 1.

According to Pecharromán and Veiga (2017), rotary-wing UAVs dominate the global market, with a participation of 77%. Fixed wingers hold 21%, as their customer base is smaller and higher priced, and hybrids (inclined wing) represent an innovative concept, still without expression in the market.

Table 1 - Differences between multi-rotor and fixed wing UAVs

Type	Advantages	Disadvantages	Typical uses
Multi-rotor	• Greater ease of use • Operation in confined areas • Static flight • Vertical take-off and landing (VTOL) • Lower cost	• Low flight range • Lower load capacity • Lower cost • Limited speed • Lower flight resistance	• Short period operations. • Aerial photos • Filming • Entertainment
Fixed wing	• Great flight range • Higher speed • Larger coverage area • Higher load capacity • Great flight resistance	• Greater operational complexity • Higher cost • Lower overall accuracy of obtained data	• Aerial photos • Aerial mapping • Remote sensing • Long distance inspection

Source: Boon, Drijfhout e Tesfamichael (2017); Chapman (2016); Gomes (2016).

Among other UAV models, we can mention, for example, helicopters (which represent only a small niche market) and hybrids (represent an innovative concept, but still without commercial expression). Helicopters (also known as heli-drones) have greater efficiency over multi-rotors, especially for their resistance, due to a general aerodynamic rule (the larger the rotor blade and the slower it rotates, the higher its efficiency is), which gives it a bonus point: the possibility of static flight with a heavier load. Its disadvantages are complexity, cost and vibration, as well as the danger posed by its large rotating blades. Hybrids, with various types under development, combine the benefits of fixed wing UAVs with static flight capability, and can also take off and land vertically. They still show operational difficulties such as stability, but this has been corrected with technological improvement (CHAPMAN, 2016).

DRONE – This is just a name, without technical support in legislation. It is a generic and informal name that has been spreading as a characteristic of any unmanned flying object, for any purpose (professional, recreational, commercial, defense or security), origin or structure. Note that not every drone can be considered a UAV, since, because it is used as a hobby or sport, it fits, by legal definition, the legislation pertaining to model aircraft, not UAV.

RPA – There are two different types of UAV. The most known and used worldwide is the RPA (Remotely Piloted Aircraft). In this situation, there is no pilot on board, but the aircraft is controlled remotely by the interface of a device (computer, simulator, remote control etc).

The other type of UAV is known as “Autonomous Aircraft”, which does not allow operator intervention during the flight, from its programming. In Brazil, its use is prohibited. Thus, RPA is the appropriate terminology for reference to non-recreational UAVs.

RPAS – Remotely Piloted Aircraft System. According to the Department of Airspace Control – DECEA, "4.2.4 (...), an RPAS consists of a RPA (aircraft), a RPS (remote piloting station), the piloting link (also called Command and Control Link or C2 Link) and associated components such as launch and recovery systems, communication equipment, navigation, flight management, autopilot and emergency and flight termination systems, among others" (BRASIL, 2017c, our translation). Remotely Piloted Air System is also a terminology used by some institutions. The term technically adopted by the International Civil Aviation Organization – ICAO and DECEA, specified in the ICA 100-40 (BRASIL, 2017c) with international scope, is Remotely Piloted Aircraft System.

4 Applicable regulation in Brazil

Unmanned Aircraft Systems (UAS) are a new component of world aviation that operators, industry and various international organizations are studying and working to understand, define and ultimately promote their complete integration into airspace. Relying on various types, sizes, performances and applications, the regulation of the use of a UAV is complex and has been a challenge worldwide for a number of issues, especially those related to the fact that there is no pilot on board (MAGELLA, 2016, p. 11).

In Brazil, we have already seen many advances, with the creation of the recent and necessary legal framework. The National Civil Aviation Agency (ANAC), the National Telecommunications Agency (ANATEL), the DECEA and the Ministry of Defense (MD), each in its area of competence, are the institutions that legally guide, control and supervise the use of UAVs, for any purpose, with its regulations embodied in the Brazilian Aeronautical Code – CBA (Law 7.565/86) (BRASIL, 1986).

In addition, the activity is not exempt from compliance withthe laws regarding civil, administrative and criminal liability that may apply to the use of unmanned aircraft, with special emphasis on those provisions regarding the inviolability of intimacy, privacy, honor and people's image. Although current legislation does not apply in its entirety to the use of UAVs in Defense and Security activities (with the exception of DECEA regulation), it does not seem permissible for operators in these areas not to know it, or to know only the parties that concern their operations.

The **ANAC** (2017c)**,** through the Brazilian Special Civil Aviation Regulation – RBAC-E nº 94, addresses the general requirements of its competence for unmanned aircraft. It legislates on the entire chain of activity, from authorization for new aircraft manufacturing projects to flight regulations, such as operational risk assessment[6].

Generally speaking, regulation is based on the aircraft's Maximum Take-Off Weight (MTOW) rating. Unmanned aircraft with a maximum takeoff weight of up to 250 grams do not

6 It means the assessment of the consequences of a hazard, expressed in terms of probability and severity, with reference to the worst possible condition. See Ordinance No. 1.474 /SPO, of May 02, 2017 (ANAC, 2017a).

need to be registered with ANAC or identified. Similarly, they do not need to have third party damage insurance (ANAC, 2017c).

Class 1 – RPA with maximum takeoff weight > 150 kg;

Class 2 – RPA with maximum takeoff weight > 25 kg and ≤ 150 kg; and

Class 3 – RPA with maximum takeoff weight ≤ 25 kg.

And, to make the regulation easier to understand, ANAC (2017b) published, in May 2017, the document "Guidance for drone users."

ANATEL's protagonism concerns radio frequency. Its control serves to prevent radio frequency transmitters, present in the remote controls of the equipment, from generating interference in other services, such as satellite communications. ANATEL's supervision is based on the mandatory approval to which UAV operators are subject, whose guidance is available in the "User's Manual" (ANATEL, 2017).

DECEA, as the central agency of the Brazilian Airspace Control System (SISCEAB), has as its scope the regulation of responsibilities and procedures necessary for safe access to Brazilian airspace. Regarding the scope of this article and among the various publications in force, we selected five.

1. Instruction ICA 100-40: Remotely piloted aircraft systems and access to Brazilian airspace. This instruction is applicable to all operations that are not exclusively for recreational purposes, that is, that do not include model aircraft (BRASIL, 2017c). We highlight the following:

    a. The RPAS Airspace Access Request System (in which military aircraft should also be registered) is a system that facilitates the recently restructured airspace access request process that works on a web platform (BRASIL, 2017a); and

    b. the NOTAM[7] (Notice to Airmen) Guidance, which is defined as "the notice containing information concerning the establishment, condition or modification of any aeronautical installation, service, procedure or hazard, the prompt knowledge of which is indispensable for the personnel responsible for flight operations" (our translation). When operating under the General Air Circulation rules, RPAS operations should follow the provisions of this Instruction. If they are operating under the rules of Military Operational Circulation, they should follow the specific document, the ICA 100-13.

2. AIC N 17/18, effective on January 2nd, 2018: aircrafts remotely piloted for recreational use — model aircraft (BRASIL, 2017b).

7 A NOTAM aims to disclose in advance aeronautical information of direct and immediate interest for the safety and regularity of air navigation (BRASIL, 2017c, p. 37).

3. AIC N 23/18, effective on January 2nd, 2018: aircrafts remotely piloted for use to the benefit of federal, state or local government agencies. These include, among others, the aircrafts employed by the Fire Department, the Military and Civil Police and the Municipal Guard. Note that this instruction provides: "NOTE 2: Military aircraft operators will be automatically recognized as RPA pilots if they meet at least one of the following: (a) Aviation Officers (QOAV) of the Brazilian Air Force; or (b) have QOAV-equivalent training in other forces (Brazilian Navy and Brazilian Army)" (BRASIL, 2017a, p. 10, our translation).

4. AIC N 24/18: Remotely piloted aircraft for exclusive use in operations of the public security, Civil Defense and IRS supervisory bodies (operations carried out with organic remotely piloted aircraft). This Instruction states that they are understood as Public Security Bodies (BRASIL, 2018, p. 1-2): Federal Police (FP), Federal Highway Police (FHP), Federal Railway Police (FRP), Civil Police (CP), Military Police (MP) and Military Fire Brigade (MFB).

5. Instruction ICA 100-13 (Air traffic rules for military operational circulation). It addresses the regulation of the use of RPAS by the organic units of the Armed Forces. For the context of this study, this is the most specific publication, obviously classified as RESERVED. For this reason, we will no longer comment here.

Finally, the **MD**, through the Head of Logistics and Mobilization of the Joint Armed Forces General Staff (CHELOG/EMCFA), is responsible for controlling the aerial survey activities, in compliance with Decree-Law No. 1,177, of June 21, 1971[8]. "This control is conditional on the registration of aerial survey entities in the MD and the authorization of their projects, in order to maintain full knowledge, by this Ministry, of the aerial survey areas in the country and to avoid aerial surveys in areas not allowed, for national security reasons." (AEROLEVANTAMENTO..., 2015, p. 1, our translation). The Armed Forces, as well as other federal agencies, are exempt from this registration, according to Normative Ordinance No. 953/MD, of April 16, 2014.

5 Use of Rpas in the brazilian armed forces

The Armed Forces began their operations with RPAS, aiming at its use as an air target. Interest in employment for other purposes grew after US results in operations in Iraq and Afghanistan.

8 "Art. 3rd: For the purposes of this Decree-Law, aerial assessment is understood to be the combination of air and/or space operations of measurement, computation and recording of terrain data with the use of appropriate sensors and/or equipment, as well as the interpretation data collected or their translation in any form" (BRASIL, 1971, p. 1, our translation).

In 2010, the Air Force acquired four units for doctrinal development and, in April 2011, two Hermes 450 manufactured by Elbit were received[9]. These aircraft allowed the deployment of the first UAV squadron at the Santa Maria/RS Air Base. Subsequently, this fleet was expanded with two Hermes 900, from the same manufacturer. (PERCHARROMÁN; VEIGA, 2017, p. 20).

In the Navy, although UAVs are also used as air targets, we focus our observation on the application of RPAS by the Brazilian Marine Corps (BMC) Aerotactic Control and Air Defense Battalion (BtlCtaetatDAAe), the most specific reconnaissance unit. The RPAS used is the Horus FT-100 (Figures 2-1 and 2-2), acquired from FT Flight Tech Sistemas SA (São José dos Campos/SP) in March 2016 for R$ 1,300,000.00. The system consists of 02 Horus FT-100 (aircraft), a Ground Station, 02 gyro-stabilized cameras with dual EO/IR (electro-optical and infrared/thermal) sensors, supplies, operator training, maintenance and technical assistance. BtlCtaetatDAAe also has other fixed wing UAVs, specifically used for training of operators.

Figure 2-1 - Horus FT-100 (BMC)

Fonte: Beni (2016).

Figure 2-2 - FT-100 Ground Station

Fonte: Beni (2016).

Also in the BA, RPASs have been used for some time, though still modestly, for various purposes. To name a few more recent and well-known applications: (i) Operation Ágata, where, since 2011, supported by the Joint Armed Forces General Staff (EMCFA), large-scale actions have been undertaken to strengthen the security of nearly 17 thousand kilometers of land borders in Brazil. It is part of the Federal Government's Strategic Border Plan (PEF), created to prevent and repress criminal activity in Brazil's border with ten South American countries (OPERAÇÃO..., 2014); (ii) operations during the 2014 World Cup (using four[10] Carantá model two UAVs (the same one already used by BMC/BN), one Dragonfly and another Orbis model, manufactured by Santos Lab) and (iii) the 2016 Olympic Games.

At Minustah (Figure 3), RPASs were used as a command and control tool (C2), providing aerial images. Although we have not obtained this confirmation, it is very likely that the RPASs currently in place at the 11th Bda Inf L units[11] will be those used by the BAat that time.

9 Read AEL Sistemas, a Brazilian company belonging to the groups Elbit Systems Ltda and Embraer Defesa e Segurança.

10 Two of the Carcará model (the same one already used by BMC/BN), one Dragonfly and another of the Orbis model, manufactured by Santos Lab.

11 Manufactured by the company SZ DJI Technology (China), model Phantom, acquired in Miami/USA in 2014, at a cost of U$ 3,000 (FREITAS, 2015).

Figure 3 - RPAS operating in Haiti (DJI Phantom)

Source: Drones... (2016).

In November 2015, the BA had already acquired three Horus FT-100 RPASs (configuration identical to BMC) for the total amount of R$ 3,719,821.36. This acquisition was based on Ordinance No. 227 – EME of September 22, 2015, which approved the standardization of the RPAS Horus FT-100. The standardization is the result of Special Committee Opinion no. 04/2015 for the standardization of materials for use by the BA. Of these three RPASs, one was allocated to the 9th Field Artillery Group (FAG) in Nioaque/MS, and two to the Parachutist Precursor Company (Cia Prec Pqdt) in Rio de Janeiro - RJ.

The BA is currently estimated to have six RPASs in this standardization. This equipment is suitable for reconnaissance missions, considering — among other features — its ability to provide geo-positioning and, as mentioned before, thermal sensor, enabling night operation. The UAV weighs 8 to 10kg and nominally has a range of 90 to 150 minutes, a range of 15 km and can fly up to 12,000 feet.

We have found that the batteries of existing BA equipment (same as BMC) have an average operating time of one hour at an altitude of 3,000 feet. Two other observations, which provide an opportunity for improvement: (i) regarding relative fragility: as the UAV landing is through a parachute located on its "belly", it reaches the ground inverted, which sometimes causes the breakdown the wing and/or tail; (ii) at higher altitudes, camera zoom is poor.

The Cia Prec Pqdt uses the FT-100 in its reconnaissance operational missions and additionally utilizes the DJI Phantom IV (it has 3 units). This additional/complementary use is important and often necessary, since Phantom can be used to provide optimal quality images in smaller and/or confined physical spaces. This complementarity has been positive, particularly in recent Garantia da Lei e Ordem (GLO – Law and Order Assurance) missions, where the Cia Prec Pqdt has often acted in support of the various units involved. It is important to highlight, however, that there are other models, from DJI itself and from other manufacturers, more suitable for military use. As an example, we refer to the Black Hornet PRS, manufactured by Flir System, Inc. The equipment draws attention for its operational characteristics, presenting valuable capabilities for gaining immediate situational awareness.[12]

12 Known as "nano drone", it has extreme portability (weighs 33 grams, 16.8 cm long), is very quiet and does not interfere with airspace, and can fly up to 2 km, with autonomy of 25 minutes. It can be used in both day and night operations, with good performance in confined spaces. It is currently used by many countries, such as the USA, France, and Australia (https://www.flir.com/products/black-hornet-prs/).

6 Operational mission of the Mechanized Cavalry Platoon and the use of Rpas

6.1 Operational mission

This is how the reconnaissance activity is defined: “it is an operation conducted in a campaign, by the use of land **or aerial** environment, with the purpose of obtaining information about the enemy and the area of operations” (BRASIL, 1999, p. 3-2, our emphasis and translation). Air assets, when available, increase speed, fronts and depth of recognition. The same document states that “Mechanized cavalry is the most appropriate element of ground forces to conduct any kind of reconnaissance. Its characteristics, organization and instruction make it highly capable to perform such missions” (BRASIL, 1999, p. 8-7, our translation).

According to the Cavalry employment doctrine, among the basic aspects that characterize what is understood as “modern combat”, we highlight: (i) greater need for information and security; (ii) faster operations; (iii) synchronization of actions; (iv) (...) and (v) demand for greater leadership, initiative, agility, synchronization, and information management capacity by commanders at all levels (BRASIL, 1999, p. 1-3).

These aspects are directly addressed when referring to the use of RPAS as a recognition tool. The other aspects listed in the referenced doctrine are, so to speak, a consequence of the quality of acquisition of the four aspects mentioned.

Pel C Mec is the smallest operating force of Mechanized Cavalry — its basic element of employment — thus becoming the “front line” regarding the reconnaissance function and others, especially safety.

According to Campaign Manual C 2-20 – Mechanized Cavalry Regiment, “Recognition and security complement each other and are closely linked. A reconnaissance mission provides a certain degree of security, notably in reconnaissance missions that seek intelligence on the enemy” (BRASIL, 2002, p. 62, our translation). It is therefore natural that the training and availability of material to Pel C Mec should have as its principle the expansion of its recognition capacity, which provides increased information gathering.

With the effective 36-man standard, Pel C Mec is organized into five teams:

1. <u>Command Group</u>: 03 men (commander, radio and driver), boarded in a light tactical vehicle (LTV) — currently the Agrale Marruá AM2;

2. <u>Group of Explorers (G Exp)</u>: is responsible for the execution of several actions, among others, those of recognition. It has a staff of 12 men, divided into two patrols. Each patrol uses two LTV — it is “seeing and speaking”;

3. <u>Armored Reconnaissance Vehicle Section</u> (Seç VBR): With the effective of six men, it is the shock element of Pel C Mec (reconnaissance, security, defense and attack). It is endowed with two ARV EE-9 Castavel — it is the “seeing and shooting”;

4. Combat Group (CG): it uses the Urutu or Guarani armored personnel carriers (APC), with a garrison of 10 men (08 marines, 01 gunman and 01 driver), engaged in combat on foot.

5. Support Piece (Pç Ap): is the fire support element (mortar) of the Pel C Mec, normally responsible for rear safety. It consists of 05 men, using an Agrale Marruá cargo car.

According to Mesquita (2014), the structure of the Pel C Mec, of combined weapons, is identical to the structure of its similar (Army Cavalry Platoon), being related to the influence of that doctrine on the BA.

6.1.1 A Brief Approach: Security, Counterintelligence (C Intlg) and Counter-reconnaissance (C Rec)

Among the affected missions to the Mechanized Cavalry units are mainly reconnaissance and security. As mentioned before, recognition is an activity in which information is a critical aspect.

The elaboration and success of any planning depends on the quality (relevance, credibility, timeliness, comprehensiveness, etc.) of the available reports[13], which, due to the ability of the RPAS (real time image availability) employed in the recognition activities, can be accepted as information. Likewise, information is critical for decision making (at any level), even if it is not originally included in a planning process, that is, it needs to be taken to the extent that the immediacy produced by new (unforeseen) facts require it.

The security mission has as its scope a set of measures to varying degrees (protection, cover and surveillance), with the main purpose of preserving the troops against surprise and observation by the opposing force. Most security is provided by C Rec activities, where the use of RPAS expands its conditions.

Information also represents the intelligence work base for both friendly forces and opponents: "it is intended to obtain, through detailed and centralized planning, specific knowledge about a particular geographical area or human activities" (BRASIL, 1999, p. 144, our translation). Therefore, the actions of the C Intlg are highly necessary. Among C Intlg's purposes are "Preventing an actual or potential enemy force from acquiring knowledge about our battle order, material situation, personnel, plans, vulnerabilities and possibilities" and "Thus, C Intlg must detect, identify and analyze the enemy threat from human sources, signals, images, cybernetics and others, planning actions and measures to neutralize or eliminate these threats" (BRASIL, 2016, p. 51, our translation).

C Rec translates into a set of measures that permeate, in particular, missions of security, intelligence and counterintelligence. "Counter-Reconnaissance is intended to destroy or neutralize the enemy's reconnaissance elements" (BRASIL, 1999, p. 46, our translation).

13 Reports are data obtained by any means. Information is the confirmed reports.

In this regard, one must keep in mind that the opposing force can also use RPASs in its reconnaissance missions. Thus, we will stick only to the aspect of the possible neutralization of a UAV, used in reconnaissance mission by the opposing force, through equipment that increases the effectiveness of C Rec actions, by the possibility of its early location. Technically, for an aircraft to be detected by primary radar, it must have a minimum size of approximately $2m^2$ or have a transponder that sends electronic signals to secondary radars. About 80% of RPASs worldwide are small and unable to fly with the equipment. Therefore, there is the difficulty of detection by traditional systems.

In our field research, we identified the DroneBlocker 0100[14] (for military applications), equipment capable of blocking a radio-controlled UAV over long distances. The use of the equipment eliminates the need for operators, with independent operation, having been successfully used by BA during the Rio 2016 Olympic Games. It should be clear, however, that this equipment does not have features for neutralizing a non-radio operating UAV. There are already UAVs operated through Bluetooth connection with a smartphone and others whose connection is via satellites.

6.2 The use of Rpas

Considering the organizational structure of the Cavalry and observing the doctrines that guide the requirements and possibilities of employment, we set the focus of this study on reconnaissance missions, naturally extended to those of C Rec and Security, where the reconnaissance activity is paramount.

From the existing knowledge, the observations made and especially the documentary references already cited, the benefit offered by the use of RPAS by Pel C Mec is more than clear. This tool offers a great ability to observe, identify and locate, assisting the action of G Exp.

It is noteworthy that the use of this feature does not replace that provided for in the original doctrine of reconnaissance; it is complementary, as Rosenberger (2004) wrote in “Breaking the Saber”. It should also be noted that perhaps the greatest advantage in its use is the physical preservation of men, as it greatly minimizes exposure to the risk of slaughter, with access to relevant and up-to-date information, allowing for greater accuracy and agility in decision making.

As already seen, the use of RPAS is pointed out in more than one reference document produced by the BA. In particular, there is the Annex “E” – Essential Elements of Doctrinal Information – of the Plan of Development of Terrestrial Military Doctrine 2016/2017 (BRASIL, 2015), as shown in Chart 2.

14 Manufactured by IACIT Solucoes Tecnológica S / A, in São José dos Campos, it monitors, detects and acts against *drone*/UAV attacks.

Chart 2 - Essential Elements of Doctrinal Information (EEDI)

ITEM	EEDI	AUTHOR'S CONSIDERATIONS
2 - INTELLIGENCE	"d. What means with aggregate technology are employed for intelligence activity?" "k. What is the observation material used by the fractions that perform reconnaissance actions? (Mat type, observation range etc.)"	d. The basis of intelligence activity is good information, in which the use of RPAS greatly contributes operationally. k. See the characteristics of the RPAS operation.
3 - FIRE	"e. Can RPAS be used to observe and conduct field artillery fire?"	Undoubtedly, the features and capabilities of RPAS operation are favorable.
5 - COMMAND E CONTROL	"g. Are there direct support tactical modules to meet the needs of combat units with regard to Geointeligence (in Brazil, Geoinformação)? If so, how is it employed?"	RPAS has geoinformational capacity.
8 - SPECIAL OPERATIONS	"f. What are the vehicles, the equipment intended for the acquisition of targets and the aid to the conduct of the air fire (laser designators, ground plane means of communication, among others), remotely piloted aircraft systems (RPAS), intended for the FOpEsp of the Armed Forces (AF), particularly those of the Army?"	Undoubtedly, the features and capabilities of RPAS operation are favorable.

Source: our elaboration, from Brasil (2015)

This direction also finds support in Mesquita (2014), in his study "A Brigada de Cavalaria Mecanizada na Transformação da Doutrina", in which he suggests the "modernization in the C Mec fractions of the Bda C Mec"[15]. From these suggestions, we selected those directly related to the focus subject of this study, which are shown in Chart 3.

Chart 3 - Suggested upgrades to C Mec fractions of the Bda C Mec

Fraction	Suggested upgrades
RC Mec	• Combat in low visibility conditions • Perform night operations • Having a RPAS
Esqd C Mec	• Having ground surveillance (not necessarily radars) • Able to operate supported by Av Ex and RPAS • Arrange provisional platoons • Combat in low visibility conditions • Perform night operations
Pel C Mec	• Having ground targeting means • Having film and photography media capable of real-time data and voice transmission

Source: Author's adaptation, from Mesquita (2014)

15 Our translation.

6.2.1 RPAS definition and standardization

Considering the current employment profiles, according to recognition needs, it is necessary to observe the possibility of using two RPAS configurations:

1. the Horus FT-100 (fixed wing), already standardized and in use, which has longer range, higher altitude operation and geolocation capability;

2. a multi-rotor SARP (as a reference, the DJI, also existing in the BA). This RPAS does not have the capabilities of the FT-100 and its battery lasts an average of 30 minutes. However, it is very useful for flights in more restricted areas (where it is not possible to use the FT-100) and also offers excellent quality images in real time.

Thus, further standardization of a multi-rotor RPAS is suggested.

6.2.2 Strategic Definition (or lines of action for the RPAS operation)

According to Mesquita (2014), the transformations that are being developed in the BA are strongly influenced by the doctrine employed in the US army. For this reason, we sought some data on the use of RPASs in that army.

Fox (2017), in his study "The State of the Cavalry: An Analysis of the U.S. Army's Reconnaissance and Security Capability" on the US Army, states that "At the most elementary level, reconnaissance and security operations are conducted on the ground and in the air. Therefore, all echelons of command must maintain organic ground and air reconnaissance and security capabilities."

Within the US Army structure, the battalion has a reconnaissance and UAVs squad, and the BCT (Brigade) has the cavalry squad and the operations with UAV squad. However, Fox, opposing the current direction of Cavalry missions — with regard to reconnaissance — argues for the existence of organic elements of reconnaissance and security at the division and army command levels, because "as the echelon of command increases, so too does its need for multidimensional reconnaissance and security assets."

However, our analysis offers a counterpoint, based on the fact that the high need for high command recognition (namely information) is obvious, but this does not need necessarily to be met at the high command level, as subordinate operational levels have exactly that responsibility.

On the other hand, the effectiveness of RPAS operation above R C Mec needs to be observed, which is not so clear. At this point, we are in agreement with Mesquita (2014) in his suggestions for modernization (see Chart 3), as explained below.

Operationally, the Pel C Mec is "the tip of the spear", having in its G Exp the most particular recognition function. For this reason, we believe that the use of RPASs will always be more effective from Pel C Mec. However, it appears that its current structure, due to its attributions and endowment, does not show conditions to assume responsibility for this employment. Thus, our suggestion is to create a specific team/section, which would be added to the current platoon structure, which, for the purpose of this study, will be identified as Section RPAS (Sec RPAS).

This Sec RPAS would be composed of 03 men (operator, launcher and observer, one of them being the commander), boarded in an LTV. Briefly, the Pel C Mec Sec RPAS would be structured as[16] follows: 01 FT-100 RPAS, 01 multi-rotor RPAS, 03 men and one LTV.

Considering the C Rec and Security aspects, RC Mec would also have a Sec RPAS, operated by the Command and Support Squadron (Esqd C Ap). For Esq C Mec, there would be no need for Sec RPAS because of the existing allocation in their Pel C Mec. Any Sec RPAS could be requested, considering the need and flexibility of employment, composing a provisional structure. According to this suggested **viable model**, each RC Mec would be equipped with 09 Sec RPAS in the Pel C Mec and one additionally equipped with a UAV blocker to provide C Rec and Security (see section 6.1 "A Brief Approach: Security, Counterintelligence (C Intlg) and Counter-reconnaissance (C Rec)").

7 Logistical aspects

In an overview of the most representative logistical aspects for the systematic use of RPAS, the acquisition, maintenance and training process (with comments that include knowledge of the relevant legislation, the operation itself and maintenance) were addressed.

7.1 Acquisition process

From the official standardization of RPASs, it is possible to make acquisitions through "exemption from bidding", using the benefits provided by Law 12.59/2012 (RETID), with the previous accreditation of its manufacturers in the Defense Industrial Base (DIB), complemented by the previous qualification of the Federal Revenue (RFB).

Law 8.666/93 shall be used in a subsidiary manner, in view of its Art. 24. "The bidding is unnecessary: (...) XIX – for the purchase of materials for use by the Armed Forces, except for personal and administrative materials, when there is a **need to maintain the standardization** required by the logistical support structure of naval, air and ground means, upon the opinion of a committee consisting of decree" (BRASIL, [2001], emphasis added, our translation). It is worth remembering that, in negotiations with manufacturers, it is necessary to observe the price reduction percentages, due to the benefits of RETID.

7.2 Maintenance

For the maintenance of RPASs, the following aspects must be met:

1. preventive maintenance – establishment of routines (1st step – part of the operators training);

16 There are 3 UAVs, considering that the RPAS Horus FT-100 consists of two aircrafts.

2. ability to perform preventive and/or corrective maintenance (2nd step);

3. immediate spare parts and accessories stock.

On December 2, 2012, ANAC approved RBAC No. 43 (Amendment No. 01), which addresses "Maintenance, Preventive Maintenance, Reconstruction and Alteration". This document should be observed as a support to the composition of maintenance programs.

7.3 Training

In any activity, the human factor needs to be strategically considered. The SARP operation, due to its relative complexity, requires specific and adequate training of all personnel involved, especially regarding the following items. And, in light of what was mentioned during the study, we seek to present a generic suggestion regarding the instructional needs for training in these areas.

1. **Basic knowledge of topography, geolocation and meteorology:** The FT-100 RPAS has requirements for filming, photographing and georeferencing (terrain profile, obstacles, fixed and moving targets, etc.). Understanding of flight characteristics is necessary to recognize the influences of wind speed, temperature, altitude and UAV speed — relations/conditions that affect it.

The Cia Prec Pqdt's operational flights have been found to deliver good results, in large part because of their operators' existing knowledge, due to the characteristics of natural formation for the precursor activity.

Therefore, for the training related to this subject, it is suggested that the responsible instructors be recruited at Cia Prec Pqdt. This is an aspect that leads to practicality, since two knowledge is combined in the same instruction team: the specific and what concerns Operation RPAS (2), below.

2. **RPAS operation:** RPASs (standardized and in the process of standardization) have specific technological characteristics due to their use. A strong understanding of RPASs is required, not only to make the most of their capabilities, but also to maintain their physical integrity.

3. **Legislation:** This is a sensitive aspect, as, in the event of an accident, the relevant regulations must be complied with in order not to create unnecessary problems. As a source of instruction for this content, it is suggested the collaboration of a professional of the Air Force Command/DECEA, in view of the main origin of the legislation. It should be remembered that the ANAC document RBAC no. 43 (Amendment No. 01) (referenced above: Maintenance, p.18-19) is also a component of applicable law.

4. **Recognition:** In view of the need for a new doctrine (now expanded), a new training standard in RPAS recognition is needed. The instructor(s) responsible shall be assigned as determined by the competent command. However, attention should be paid to the detail that this/these instructor(s) should participate, preliminarily, in the instructions detailed in items (1) and (2) above.

5. **Maintenance:** Refers to the maintenance of the systems. It is important to define the basic process from the manufacturers. We refer to the establishment of a planned/scheduled maintenance program, with the respective maintenance routines, considering the levels of such activity (1st: operators; 2nd: designated maintenance unit; 3rd: manufacturer). It should always be borne in mind that proper maintenance is primarily responsible for compliance with the equipment's life cycle as originally intended.

This instructional content demands two steps.

Step 1: destined for those responsible for 2nd level maintenance operations (designated unit). Its development should be carried out by manufacturers' professionals, which should be negotiated upon the acquisition of RPASs.

Step 2: Intended for operators, for basic maintenance. This simpler step should be conducted by the designated maintenance unit.

In order to assist in addressing and prioritizing the main action needs (which are obviously not fully represented), the result of the application of the GUT Analysis/Matrix[17], a management support tool, is shown below (see Table 1). Simply designed, this tool assists in the formation of strategies, project management and information gathering, based on their definitions.

The application of this matrix considers the Gravity, Urgency and Tendency (GUT) of the analyzed situation/problem, whose aspects are scored as follows:

Gravity (G)

5 = extremely severe; 4 = very severe; 3 = severe; 2 = not very severe; 1 = no severity.

Urgency (U)

5 = needs immediate action; 4 = is urgent; 3 = as soon as possible; 2 = little urgent; 1 = can wait.

Tendency (T)

5 = will get worse quickly if nothing is done; 4 = will get worse soon if nothing is done; 3 = will get worse; 2 = will get worse in the long run; 1 = will not change.

17 The **GUT** Priority Matrix (Gravity x Urgency x Tendency) was proposed by Charles H. Kepner; Benjamin B. Tregoe (1981), as one of the tools used in problem solving. It is a quality tool used to set priorities given to various action alternatives.

Table 1 - GUT Analysis/Matrix

Actions required	G	U	T	G × U × T	Solution order
A. Definition and standardization of multi-rotor RPAS (or other model for the same purpose)	5	5	3	75	**3**
B. Definition and standardization of anti-drone equipment (blocker)	5	5	3	75	**3**
C. Making and disseminating specific doctrine (Operation RPAS)	4	4	1	16	**7**
D. Strategic definition and delivery schedule of contemplated OMs	5	5	1	25	**5**
E. RPASs acquisition schedule (budget dependency)	5	4	1	20	**6**
F. Definition of the composition of the operator structure (personnel strategy)	3	3	1	9	**9**
G. Training of operators	3	3	1	9	**9**
H. Definition of capacity structure	3	4	1	12	**8**
I. Definition of the organizational structure (and general reporting) of the RPAS operation[1]	5	5	4	100	**1**
J. Maintenance Structure	4	5	3	60	**4**
K. Acquisition process (elaboration)	4	5	1	20	**6**
L. Definition and negotiation with suppliers	4	4	1	16	**7**
M. DIB Accreditation and qualification Actions	4	4	1	16	**7**
N. Definition of UAV blocker usage and standardization	5	5	3	75	**3**
O. Purchase of new batteries for FT-100 (longer life)	4	5	4	80	**2**
Q. Purchase of additional batteries for multi-rotor RPASs currently in use	4	5	4	80	**2**

Source: elaborated by the authors (2019).

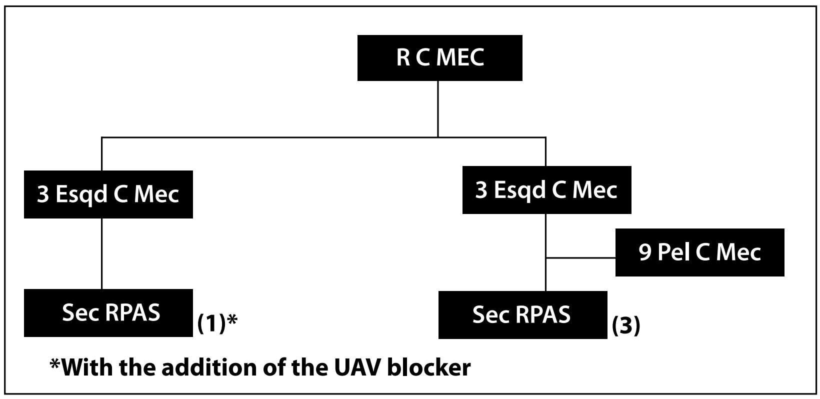
8 Final considerations

The BA is currently undergoing a deep transformation process, based on strategic projects that seek to create new skills, tailored to the needs of the "knowledge age". In this context, the systematic use of RPASs by the Pel C Mec, due to the facts and reasons exposed throughout this study, is strongly recommended.

However, considering the current economic situation and the high cost of implementing the **viable model** suggested in item 6.2.2 (p. 17), a more realistic option from a budgetary point of view (synthetic demo in Chart 4) is shown, with a **reduction from 10 to 04 Sec RPAS**, which may also meet the operational needs already discussed, according to experts on the subject, interviewed throughout the investigation. Rather than being exclusively dedicated to Pel C Mec, each RC Mec would be endowed with 04 Sec RPAS: one in each Esqd C Mec and one in the Esqd C Ap. The latter would be additionally equipped with a UAV blocker.

Operationally, it will be up to the commander of each of the three Esqd C Mec to define their Sec RPAS application for enhancing the reconnaissance ability of the Pel C Mec (purely strategic decision).

Chard 4 - Synthesized structure of the suggested option



Source: elaborated by the authors (2019).

From the priorities identified as a result of the GUT Analysis (the author's understanding), the next step should be developing action plans, with allocation of responsibilities, budgets and schedules, listed in Table 2.

Table 2 - Priority order for basic actions

Required actions	Priority order
H. Definition of the organizational structure (and general reporting) of the RPAS operation	1
N. Purchase of new batteries for the FT-100 (lasting two hours)	2
O. Supplementary battery purchase for multi-rotor RPASs in use	2
A. Definition and standardization of multi-rotor RPAS	3
M. Definition of UAV blocker usage and standardization	3
I. Maintenance Structure	4
C. Strategic definition and delivery schedule of contemplated OMs	5
D. RPASs acquisition schedule (budget dependency)	6
J. Acquisition process (elaboration)	6
B. Making and disseminating specific doctrine (Operation RPAS)	7
K. Definition and negotiation with suppliers	7
L. DIB accreditation and qualification actions	7
G. Definition of capacity structure	8
E. Definition of the composition of the operator structure (personnel strategy)	9
F. Training of operators	9

Source: elaborated by the authors (2019).

References

AEROLEVANTAMENTO. **Ministério da Defesa**, Brasília, DF, 28 out. 2015. Available at: https://bit.ly/2DY8Edp. Access on: Dec. 20, 2017.

AGÊNCIA NACIONAL DE AVIAÇÃO CIVIL (Brasil). **Instrução suplementar nº E94-003**: Revisão A. Brasília, DF: Anac, 2017a.

AGÊNCIA NACIONAL DE AVIAÇÃO CIVIL (Brasil). **Orientações para usuários de drones**. Brasília, DF: Anac, 2017b.

AGÊNCIA NACIONAL DE AVIAÇÃO CIVIL (Brasil). **Regulamento brasileiro da aviação civil especial**. Brasília, DF: Anac, 2017c. RBAC-E nº 94,

AGÊNCIA NACIONAL DE TELECOMUNICAÇÕES (Brasil). **Manual do Usuário SCH** – Solicitante – Declaração de Conformidade para quadricóptero (drone). Brasília, DF: Anatel, 2017. Versão 1.2.

BENI, E. A. Exército e Marinha utilizarão o VANT Horus FT-100 durante as Olimpíadas. **Piloto Policial**, [s. l.], 4 ago. 2016. Available at: https://bit.ly/2Lv9aW6. Access on: Jan. 16, 2018.

BOON, M.; DRIJFHOUT, A. P.; TESFAMICHAEL, S. Comparison of a fixed-wing and multi-rotor UAV for environmental mapping applications: a case study. **International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences**, [s. l.], v. XLII-2/W6, p. 47-54, 2017. Available at: https://bit.ly/2Wm4GSV. Access on: June 15, 2018.

BRASIL. Presidência da República. Decreto-Lei nº 1.177, de 21 de junho de 1971. Dispõe sobre aerolevantamentos no território nacional, e dá outras providências. **Diário Oficial da União**: Brasília, DF, p. 4698, 21 jun. 1971.

BRASIL. Exército. **Manual de campanha**: esquadrão de cavalaria mecanizado. Brasília, DF: Estado-Maior do Exército, 1982. C2-36. Available at: https://bit.ly/2GUkq93. Access on: Jan. 11, 2018.

BRASIL. Presidência da República. Lei **nº 7.565, de 19 de dezembro de 1986.** Dispõe sobre o Código Brasileiro de Aeronáutica. **Diário Oficial da União**: Brasília, DF, p. 19567, 23 dez. 1986.

BRASIL. Exército. **Manual de campanha**: operações. 3. ed. Brasília, DF: Estado-Maior do Exército, 1997. C 100-5.

BRASIL. Exército. **Manual de campanha**: emprego da cavalaria. 2. ed. Brasília, DF: Estado-Maior do Exército, 1999. C 2-1.

BRASIL. Casa Civil. **Lei nº 8.666, de 21 de junho de 1993**. Regulamenta o art. 37, inciso XXI, da Constituição Federal, institui normas para licitações e contratos da Administração Pública e dá outras providências. Brasília, DF: Presidência da República, [2001].

BRASIL. Exército. **Manual de campanha**: regimento de cavalaria mecanizado. 2. ed. Brasília, DF: Estado-Maior do Exército, 2002. C 2-20.

BRASIL. Exército. **Bases para a transformação da doutrina militar terrestre**. Brasília, DF: Estado-Maior do Exército, 2013.

BRASIL. Exército. **Boletim especial do exército nº 28/2014**. Brasília, DF: Secretaria Geral do Exército, 2014a.

BRASIL. Ministério da Defesa. Portaria Normativa nº 953/MD, de 16 de abril de 2014. Dispõe sobre a adoção de procedimentos para a atividade de aerolevantamento no território nacional. **Diário Oficial da União**: seção 1, Brasília, DF, p. 14, 17 abr. 2014b.

BRASIL. Exército. **Plano de desenvolvimento da doutrina militar terrestre 2016/2017 (PDDMT 16/17)**. Brasília, DF: Estado-Maior do Exército, 2015.

BRASIL. Exército. **Manual de campanha**: planejamento e emprego da Inteligência Militar. Brasília, DF: Comando de Operações Terrestres, 2016.

BRASIL. Ministério da Defesa. Comando da Aeronáutica. **Aeronaves remotamente pilotadas para uso em proveito dos órgãos ligados aos governos federal, estadual ou municipal**. Rio de Janeiro: Decea, 2017a. AIC-N 23/18.

BRASIL. Ministério da Defesa. Comando da Aeronáutica. **Aeronaves remotamente pilotadas para uso recreativo**: aeromodelos. Rio de Janeiro: Decea, 2017b. AIC-N 17/18.

BRASIL. Ministério da Defesa. Comando da Aeronáutica. **Sistemas de aeronaves remotamente pilotadas e o acesso ao espaço aéreo brasileiro**. 2. ed. Rio de Janeiro: Decea, 2017c. ICA 100-40.

BRASIL. Ministério da Defesa. Comando da Aeronáutica. **Aeronaves remotamente pilotadas para uso exclusivo em operações dos órgãos de segurança pública, da Defesa Civil e de fiscalização da Receita Federal**. Rio de Janeiro: Decea, 2018. AIC-N 24/18.

CHAPMAN, A. Types of drones: multi-rotor vs fixed-wing vs single rotor vs hybrid VTOL. **Australia UAV**, Victoria, AU, 2016. Originally published in Drone Magazine, n. 3, jun. 2016. Available at: https://www.auav.com.au/articles/drone-types/. Access on: Feb. 13 2018.

DRONES: uma possível ameaça longe dos radares. **DefesaNet**, 4 ago. 2016. Available at: https://bit.ly/2PJz07q. Access on: Feb. 2018.

FOX, M. A. C. O estado da cavalaria: uma análise do elemento de reconhecimento e segurança no exército dos EUA. **Centro de Doutrina do Exército**, Brasília, DF, 6 jun. 2017. Available at: https://bit.ly/2VHdLbQ. Access on: Mar. 9, 2018.

FREITAS, O. Militares brasileiros testam drones para operações no Haiti. **Folha de S. Paulo**, São Paulo, 20 abr. 2015. Available at: https://bit.ly/2VJhVQq. Access on: Jan. 20, 2018.

GOMES, R. Drones na agricultura: tudo sobre a tecnologia que está mudando o setor. **Pix Force**, Porto Alegre, 27 dez. 2016. Available at: https://bit.ly/2LmRjRq. Access on: Feb. 13 2018.

GRANEMANN, E. Drone Entrepreneurs Forum. **O Globo**, Rio de Janeiro, ano XCII, n. 30870, 12 fev. 2018. Negócios e Leilões, p. 3.

KEPNER, C. H.; TREGOE, B. B. **O administrador racional.** Rio de Janeiro: Atlas, 1981.

MAGELLA, P. E. A. **A operação de aeronaves remotamente pilotadas e a segurança do espaço aéreo**. Rio de Janeiro: ESG, 2016.

MESQUITA, A. A. A brigada de cavalaria mecanizada na transformação da doutrina. **Military Review**: revista profissional do exército dos EUA, Forth Leavenworth, t. 69, n. 5, p. 10-15, 2014.

OLIVEIRA, J. C. M. A torre REMAX no pelotão de Cavalaria Mecanizado. **Ação de Choque**, Santa Maria, n. 14. p. 6-14, 2016.

OPERAÇÃO Ágata. **Ministério da Defesa**, Brasília, DF, 5 ago. 2014. Available at: https://bit.ly/2WlIGrp. Access on: Fev. 15, 2018.

PECHARROMÁN, J. M. P.; VEIGA, R. **Estudo sobre a indústria brasileira e europeia de veículos aéreos não tripulados**. Brasília, DF: Ministério do Planejamento, Desenvolvimento e Gestão, 2017.

ROSENBERGER, J. D. Breaking the saber: the subtle demise of cavalry in the future force. **Association of the United States Army**, Arlington, 8 jun. 2004.

UBIRATAN, E. A origem dos vant. **Aero Magazine**, São Paulo, n. 248, 2015. Available at: https://bit.ly/2Y4yi7I. Access on: Jan. 23, 2018.

VOCÊ sabe a diferença entre VANT, DRONE e RPAS? **DronDrones**, Fortaleza, 6 jan. 2017. Available at: https://bit.ly/2HcmviO. Access on: Feb. 12, 2018.