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The Influence of Aerospace Infrastructure of the Amazon Region in Logistic Support to the Border Platoons of the Brazilian Army

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Abstract: Air transport in Amazon Region has a significant strategic importance, given the different geographic and climatic dimensions and characteristics. Part of the border strip is permanently garrisoned by the Special Border Platoons (SBP) of the Brazilian Army, representing the unfolding of the State presence in its frontier boundaries. Special Border Platoons are checkpoints of surveillance and control over transnational illicit activities besides promoting the integration of indigenous peoples and local communities and providing medical and humanitarian support. In this context, the Brazilian Air Force is primarily responsible for air-logistic transportation that supplies the SBP, transporting food, fuel, and ammunition, among others items. Headquartered in Manaus and operated by the 1st/9th Aviation Group, C-105 "Amazonas" is the aircraft most frequently engaged in providing such support, in fulfillment of the missions of the Amazon Support Plan (ASP). In places where SBPs are based, the Aerospace Infrastructure does not always have the desirable conditions for the operation of the C-105 aircraft, in view of the landing and take-off weight, the size of the runway, the type and conservation of the pavement, the weather information and radar coverage available, the Runway End Safety Area (RESA) and the nature of the missions itself. All these conditions represent factors that can affect the accomplishment of the operations, which can compromise the effective support to the SBP. This study aimed to investigate the extent to which the Aerospace Infrastructure in the SBP airfields influences the effective support to the SBP. The research is descriptive and exploratory, using bibliographic, documentary techniques and quantitative and qualitative approach.

Key words: aerospace infrastructure; air transportation; Amazon Region
JEL codes: Z01

1. Introduction

The present work analyzed the use of the Transport Aviation of the Brazilian Air Force (FAB) in support to the Special Border Platoons (SBP) of the Amazon Region, having as general objective to analyze the limiting factors generated by the Aerospace Infrastructure to the operationality of the Transport Aviation in the logistical support to the SBP under the focus of the National Defense Policy.

The strategic dimension of air transport in the Amazon Region is noteworthy, where the supply logistics for a

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large part of the SBPs is carried out by the FAB. Magalhães (2011, p. 113) reports that "due to the great distances that involve transport in the Amazon and the precariousness of surface transport structures, air transport in the Amazon has assumed strategic value for the development of the region".

The SBP are units of the Brazilian Army (EB) that permanently cover part of Brazil's border strip. These military organizations represent the presence of the State at its border limits and contribute to the maintenance of National Sovereignty and Territorial Integrity. They are border surveillance and control posts and symbolize the first barrier of the National Military Power against, for example, illegal transnational activities. They also promote the integration of indigenous peoples and local communities, providing, on certain occasions, medical and humanitarian support.

The National Defense Policy (Brazil, 2012) highlights that "the vivification of borders, the protection of the environment and the sustainable use of natural resources are essential aspects for the development and integration of the region".

The border units of the EB, mostly geographically isolated, receive, by air, personnel, armaments, food, medicine, fuels, vehicles, construction materials and miscellaneous equipment. Much of this loading is done by FAB aircraft, frequently used for air-logistical transportation that serves the SBP, in fulfillment of the Amazon Support Plan (PAA) missions. One of the air transport units of the FAB that stands out in these missions is the First Squadron of the Ninth Aviation Group (1st/9th GAv), based in Manaus-AM. The 1st/9th GAv, also called the Arara Squadron, operates the C-105 Amazonas cargo aircraft, of Spanish origin. This aircraft was acquired by the Brazilian Air Force and incorporated into the Squadron as of 2007, for having STOL (Short Take Off and Landing) characteristics and greater carrying capacity and autonomy than the previous aircraft, the C-115 Buffalo[1]. Such characteristics are essential for operation at the aerodromes of the Border Platoons, most of which have restricted airstrips[2] for the operation of airplanes.

For landing and take-off operations to be carried out safely, an adequate Aerospace Infrastructure in the SBPs is necessary in order to maintain the operational capacity of the Brazilian Air Force. The Infrastructure covers the entire set of bodies, installations or terrestrial structures to support air navigation, to promote safety, regularity and efficiency, as provided in the Brazilian Aeronautical Code (CBA) (Brazilian Aeronautical Code, 1986). However, the Aerospace Infrastructure does not always have the desirable conditions for the operation of the C-105 CASA aircraft in the locations where the SBPs are based.

The research is based on the logistical support missions to the SBP carried out by the C-105 of the 1st/9th GAv, in the localities of the Amazon Region, where the Arara[3] Squadron operates, during the period from 2007 to 2018, having excluded the year of 2019, year of the research, restricting itself to the limiting factors of the Aerospace Infrastructure to the operationality of Transport Aviation in the logistical support to the SBP.

The survey also conducted interviews (Gil A. C., 2017), with officers of the Center for Investigation and Prevention of Aeronautical Accidents (CENIPA), establishing the hypothesis that Aerospace Infrastructure

[1] The DHC-5 Buffalo was manufactured by de Havilland Canada and is a short takeoff and landing (STOL) utility transport turboprop aircraft developed from the earlier piston-powered DHC-4 Caribou. Capacity is up to 41 troops or some 18,000 lb of cargo payload and power is provided by two 3,133 hp GE CT64 turboprops. DE Havilkland Canada was incorporated by Bae Systems Plc. Available online at: https://www.baesystems.com/en/heritage/de-havilland-canada-dhc-5-buffalo, accessed on 23 March 2021.

[2] Information on the use of aerodromes, runways and navigation aids is provided by the Auxiliary Publication of Air Routes (ROTAER). The Auxiliary Publication of Air Routes (ROTAER) is produced and distributed by the Airspace Control Department (DECEA) of the Air Force Command. The purpose of ROTAER is to present aeronautical information that provides convenient and quick consultations, both in the planning phase and in the realization of a flight.

[3] Arara Squadron is the name of this Brazilian Air Force Squadron and Arara is the name of a native bird of the Amazonic Region.

existing in aerodromes in the locations of the SBP is decisive for aeronautical occurrences, limiting air operations in support of Frontier platoons carried out by the 1st / 9th Gav.

2. The Importance of the Amazon Region

The problematization is contextualized in the environment of the Legal Amazon, a vast region with distinct geographical and climatic characteristics, and defined by Bertha Koiffmann Becker (Becker B. K., 2005). as the "ecological heartland"[4] of the planet For Fuccille (Fuccille A., 2015), the region is the "most important mega-domain of tropical nature on Earth" because it has a "[…] majestic forest with the greatest biodiversity on the planet, the vast water resources, the enormous mineral wealth […]". The idea was also corroborated by Amin (Amin M. M., 2015) when he affirms that the Amazon "is an important vital space due to its territorial grandeur, its richness of natural resources and the exuberance of its biodiversity".

Thus, it is possible to observe the great political, strategic and economic importance of the Amazon for Brazil. Given this fact, it is implied that the political situation involving the Amazonian countries neighboring Brazil was and still is an important factor to be considered by the Brazilian governments in the formulation of defense policies and strategies. There are more than eleven thousand kilometers of international borders, located in a complex political situation, marked by several land conflicts, disputes between local, national and international actors, the interest of large companies, little effective presence of States and great porosity of borders.

Therefore, taking care of national defense without direct action in the border areas would be non-sense. The Amazon has always been a concern for the Brazilian government, however, in addition to the territorial guarantee, in the 21st century, there is also a concern with the development of socioeconomic areas, which starts to configure an important characteristic to achieve political and regional stability where the performance of the Armed Forces acquires a primordial character.

> The guarantee of the presence of the State and the vivification of the border strip are hampered by the low demographic density and long distances, associated with the precariousness of the land transport system, which conditions the use of waterways and air transport as the main access alternatives.[...].Vivification, adequate indigenous policy, sustainable exploitation of natural resources and protection of the environment are essential aspects for the development and integration of the region. The increase in the presence of the State, and in particular of the Armed Forces, along our borders, is a necessary condition for achieving the objectives of stabilization and integrated development of the Amazon. (Emphasis added) (Brazil, 2012, pp. 7-8).

The next item will provide a brief history of the Border Platoons and their importance for the protection of the Amazon Region borders.

2.1 Special Border Platoons

The presence of the Brazilian State at the borders is a strategic issue, addressed in the main documents on National Defense. The National Defense Strategy (END) (Brasil, 2012, p. 54) establishes, as one of the guidelines, the prioritization of the Amazon Region and reaffirms sovereignty in the region by countering foreign interests, based on the trinomial monitoring/control, mobility and presence — "who takes care of the Brazilian Amazon, at

[4] "The notion Heartland that can be understood as a pivot area, axis region, central land or continental heart — is the key concept that constitutes the touchstone of the theory of terrestrial power (...). This concept was coined by Mackinder to designate the basic nucleus of the great Eurasian mass that geopolitically coincided with the Russian borders of the beginning of the century." (Villa, 2000, p. 2).

the service of humanity and of itself, is Brazil".

Figure 1 Special Border Platoons in the Amazon Region[5]

With regard to the Armed Forces, the presence of the Army on the border limits of the Amazon Region by the deployment of several Special Border Platoons. Currently according to Cassanêgo (2017) more than 11,000 linear kilometers of frontier in the Amazon Region are guarded by 24 SBP. For Silva and Ribeiro (Silva A. B. D., 2007)

> The Special Border Platoons represent a front line in the surveillance and defense of the country's sovereignty, hindering any penetration in the border strip. The presence of the SBP is linked to the "presence strategy" that provides for the combat and resistance to external threats, acting as a defense "spearhead", in addition to fulfilling the function of "vivifying" the border, where the military begins to occupy these regions of difficult access and with low demographic density, also making illegal occupation difficult.

Silva (2007) points out that SBPs in the Amazon also play an essential role in the lives of these communities, constituting themselves as centers of socioeconomic dynamism in the locations where they are installed. Therefore, it can be said that, likewise, they promote the integration of this small, but valuable, portion of the Brazilian population. Which, in turn, also has strategic value, because, still in Silva's view (2007, p. 7), "the military presence in these areas is coated with a special strategic character, recognized as humanitarian, which attributes to the military personnel working in the area a kind of "modern heroism".

For the well-being, security and daily obligations in these small Military Organizations to be maintained, allowing the troops to be employed under the motto "life, combat and work"[6], it is essential that the logistical support works regularly. Without resources and tools there is no work, without weapons and ammunition there is no combat and without food and medicine there is no life.

[5] Available online at: http://www.forte.jor.br, accessed on August 1st, 2019.

[6] "In the SBP, it all comes down to the motto: 'life, combat and work'. And life, in this case, also involves family, leisure and survival in the SBP (cultivation, animal husbandry)." (Silva, 2007, p. 158).

For Fuccile (2015), the Brazilian Air Force acts alongside the Brazilian Army, providing essential support for the survival of the Platoons and helping the Brazilian Army, through the SBP, to fulfill its primary mission of protecting national borders. The support provided by the Air force airplanes in air-logistical transport is summed up in a sentence, of unknown authorship, and stamped on the wall of some platoons: "From the first board to the last nail, this platoon was carried on the wings of the Brazilian Air Force".

2.2 Brazilian Air Force Support

"The airplane, since the dawn of the twenties of the last century, has appeared as a solution to be tried in shortening the colossal distances between Brazilians" (Cambeses Júnior M., 2003, p. 2).

Since the creation of the Military Air Mail, in 1931, the country has never been the same. The lines to other regions of Brazil opened the interior for civil and military aviation that, until then, only flew along the coast. The idea was to create several routes to isolated places in Brazil. The Naval Air Mail was created in 1934 and after the advent of the Ministry of Aeronautics in 1941, air mail services were unified, creating the National Air Mail (CAN). At the end of that year, CAN already operated 14 regular lines and transported more than 70 tons of mail to different parts of the country[7].

> After the Catalinas airplanes were transferred from the Galeão Air Base to the Belém Air Base [in the 1950s], the Lines along the Amazon River and some of its main tributaries began to be executed more frequently. These were intended to provide support to the Border Platoons of our Army and to serve riverside populations, both struggling with immense difficulties, due to the lack of communications and the enormous distances from these locations to large urban centers (Cambeses Júnior, M., 2003, p. 7).

The aircrafts have changed, but support remains necessary. Among some of these aircrafts, we can mention the C-95 Bandeirante, C-97 Brasília, C-98 Caravan, C-130 Hércules and C-105 Amazonas, the focus of this research because is the main equipment of the 1st/9th GAv, air unit created in 1970. "Only the 1st/9th GAv dedicates 90% of its missions to logistics transport" (Konrad K. D., 2018, p. 4) supporting SBP necessities.

The C-105 aircrafts, since they started operating at the FAB, in 2007, have boosted the logistical support to the SBP, in view of their ample load capacity and autonomy, in addition to the characteristics of operation on short runways. The C-105 Amazonas is a twin-engine, turboprop aircraft, with a high wing, a pressurized cabin and suitable for transport lines over short and medium distances. It has an average cruising speed of 440 km/h, a maximum autonomy of 9 hours of flight and a maximum take-off weight of 21,000 kg[8]. These and other characteristics have made the C-105 the most used aircraft in the logistics supply of SBPs. "Another factor that makes the relationship between the Arara Squadron and the Amazon Support Program close is the C-105 Amazonas aircraft. The cargo plane is the main aerial vector of the PAA"[9] (Vasconcellos, I., 2018, p. 30).

Therefore, despite the fact that the C-105 is an aircraft planned for operation on short runways and even on unpaved terrain, it is necessary to consider a certain limitation in the operation due to the Aerospace Infrastructure available at the SBP aerodromes, above of everything, regarding the runway strips.

2.3 The Aerospace Infrastructure on the Special Border Platoons Airfields

In the delimited scope of this work, only the EB organizations (SBP) were considered, whose logistical

[7] Available online at: http://www.fab.mil.br.
[8] Available online at: https://www.airbus.com/defence/c295.html, accessed on February, 12th, 2021.
[9] In 2017, there were 3,247 flight hours to the PAA, distributed among six Air Units, with the Arara Squadron being the most employed.

support by air is regularly provided by the 1st/9th GV. Therefore, only the following locations with SBP were part of the study: Palmeiras do Javari — SWJV[10], Estirão do Equador — SWEE, Ipiranga — SWII and Japurá — SWJP (support provided from Tabatinga-AM); Pari-Cachoeira — SWPC, Yauaretê — SBYA, Querari — SWQE, São Joaquim — SWSQ and Maturacá — SWMK (support provided from São Gabriel da Cachoeira-AM); Auaris — SWBV and Surucucu — SWUQ (support made from Boa Vista-RR).

The runway strips are part of the Aerospace Infrastructure, in turn, one of the constituent elements of the Brazilian Aerospace Power. According to the Basic Doctrine of the Brazilian Air Force (DCA 1-1), Aerospace Infrastructure (Brazil, 2012, p. 36):

> It is the set of facilities and services, military and civilian, that provides the necessary support to the aeronautical and space activities of the Country. Such infrastructure is essential to promote the control and surveillance of airspace, the safety of air navigation and the safe and aviation in Brazilian airspace. In addition, the set of civil aerodromes, added to the military aeronautical infrastructure, increases the mobility of Air Force Means, as it allows the use in the different regions of the country.

For Balster (2016) the infrastructure must be understood as one of the vital elements for the air transport service, comprising airports, airlines, customers, air traffic control and aid to air navigation[11]. In relation to the delimited SBP, Tables 1 to 3 provide an overview of the following aspects related to the currently existing Aerospace Infrastructure such as: the size of the runways, the type of pavement, the weather information, the available radar coverage and the nearby elevations.

The factors presented in Tables 1 to 3 represent the basic elements for planning an operational mission for the locations where the SBPs are based. Although the C-105 is an aircraft planned for operation on short runways and even on semi-prepared runways, it is necessary to consider a certain limitation in the operation due to the Aerospace Infrastructure available in the SBP aerodromes, mainly with respect to the extension of the runways.

Table 1 Tabatinga-AM Region. Airfield Characteristics

	SWJV	SWEE	SWII	SWJP
Runway Strip Dimension	1200 × 30	1200 × 30	1500 × 30	1500 × 30
Surface	Concrete	Asphalt	Concrete	Concrete
Radio Navigation Aids[12]	NO	NO	NO	NO
Meteorological Informations[13]	NO	NO	NO	NO
Nearby Elevations	Flat	Flat	Flat	Flat
Resa[14]	YES	YES	YES	YES

Source: ROTAER[15].

[10] The four letters designate the location code corresponding to the aerodrome, by an international classification code of the International Civil Aviation Organization (ICAO).

[11] Airlines and customers were not considered in this study, given that there is no commercial relationship between the supported bodies and the supporting units (EB e FAB).

[12] Navigation aids are equipment on the ground that interacts with the aircraft's instruments and indicates the position of the emitting station, even in conditions of low visibility.

[13] At non-controlled aerodromes, the expression “Aerodrome Flight Information Service Unit (AFIS)” is used to designate a unit established at aerodrome for the purpose of providing flight information services, and also receiving reports concerning air traffic services and flight plans submitted before departure. These services include flight plan presentation, meteorological and radio navigation information’s. ANDT, AIRAC AIP, 2018, pp. 2-21. Published by Airspace Control Department, Brazil. In the SBP’s aerodromes these services are not available.

[14] Runway end safety area — RESA. BRASIL. ROTAER — Auxiliary Publication of Air Routes. Aeronautics. Airspace Control Departmentt (DECEA). Rio de Janeiro, 2018. PDF file.

Table 2 São Gabriel Da Cachoeira-AM – Region- Airfield Characteristics

	SWPC	SWQE	SBYA	SWSQ	SWMK
Runway Strip Dimension	1200 × 30	850 × 30	1600 × 30	1200 × 30	1200 × 30
Surface	Compacted Clay	Asphalt	Asphalt	Asphalt	Asphalt
Radio Navigation Aids	No	No	Yes	No	No
Meteorological Informations	No	No	No	No	No
Nearby Elevations	Flat	Flat	Flat	Montainous	Montainous
RESA	YES	NO	YES	NO	YES

Source: ROTAER.

Table 3 Boa Vista-RR Region – Airfield Characteristics

	SWBV	SWUQ
Runway Strip Dimension	1140 × 23	1080 × 30
Surface	Asphalt	Asphalt
Radio Navigation Aids	NO	NO
Meteorological Informations	NO	NO
Nearby Elevations	Montainous	Montainous
RESA	NO	NO

Source: ROTAER.

The type of pavement and, mainly, its state of conservation, are relevant data for the crew as planning factors. Of the eleven aerodromes studied, seven are made of asphalt, three are made of concrete and one is made of slate. In Photo 1, it is possible to observe that the runway pavement in Surucucu was compromised and, in a way, affecting operations in that location.

Photo 1 Surucucu's Airfield – RR.

[15] Runway end safety area — RESA. BRASIL. ROTAER — Auxiliary Publication of Air Routes. Aeronautics. Airspace Control Departmentt (DECEA). Rio de Janeiro, 2018. PDF file.

In the Photo 1, it is possible to observe, in Surucucu's runway, holes, pebbles and other loose debris that can be ingested by the engines or hit by the propellers mainly during the application of the engines in reverse[16] right after landing. There are also elevations around the runway, natural obstacles, which are relevant in the case of an operation in adverse weather conditions.

The Amazon Region has a marked rainfall, especially at certain times of the year and this can prevent landing due to weather conditions, since the landing in Surucucu, e.g., can only be done under visual conditions.

Meteorological information is important when planning flights. The knowledge of the conditions, before taking off for the SBP, is relevant, since it can prevent the landing in the desired location for having encountered unfavorable weather conditions at the destination. Even if the aircraft returns to the place of origin, the cost in unproductive flight hours must be considered. Navigation aids are not mandatory for visual flights, however, as they indicate the position of the emitting station, they are useful references, when available, especially if the aircraft does not have a reliable GPS[17]. signal. In instrument flight conditions, without visual references, these aids expand the aircraft's capacity to serve a given aerodrome. Currently, operation in SBP is only possible under visual flight conditions, that is, in favorable weather conditions for visual flight.

The runway dimensions restrict the operation in order to limit the maximum landing and take-off weights. Maximum weights are structural limits, regulated by the aircraft manufacturer. They are mainly determined according to the available runway length, altitude and temperature and previously calculated by the crew. As a rule, the smaller the runway, the lower the maximum weights. During takeoff, the aircraft must accelerate on the ground until it reaches a speed that sustains the flight and, on landing, it must decelerate to a safe speed so that it can perform the maneuvers on the ground. Therefore, reducing the maximum weight is a feature used when operating on short tracks.

Other relevant aspects for the operation are the maximum landing and take-off weights[18], which, according to the aircraft's Performance Manual, can be limited by the temperature, length and altitude of the runway and, therefore, the more cargo is loaded only once, fewer trips will be needed to carry the entire payload expected. For example, the landing at the Querari runway, which is 850 meters long, is normally carried out with less payload than at the Yauaretê runway, which is 1,600 meters long.

In addition to the type of the runways, the conservation of the strip pavement is also relevant information. Of the eleven aerodromes studied here, seven are made of asphalt, three are made of concrete and one is made of slate. Depending on the conservation of the pavement, it is possible to have pebbles and other loose debris, which can be ingested by the engines or hit by the propellers, mainly during the application of the engines in reverse right after landing. In this situation, the propeller blow is directed to the front, causing dust, sand and debris to accumulate on the pavement to be lifted, with occasional damage to the turbo-propeller assembly.

Therefore, this item sought to demonstrate the need for the existence of an infrastructure that allows the safe operation of aircraft at the SBP aerodromes, as well as the factors that often hinder the operation and may prevent

[16] The reverse is the positioning of the propellers at an angle that provides propulsion in the opposite direction to the displacement, helping to reduce the aircraft's speed right after the landing gear touches the ground.

[17] GPS is the Global Positioning System. Consists of a satellite tracking system that determines the geographic coordinates of the position of the device installed on the aircraft.

[18] Maximum landing and take-off weights are structural limits, regulated by the aircraft manufacturer. They are mainly determined according to the available track length. The smaller the runway, the lower the weights (during takeoff the aircraft must accelerate on the ground until it reaches a speed that sustains the flight and on landing it must decelerate to a safe speed so that it can perform the maneuvers on the ground).

the necessary support to the Border Platoons, compromising the mission of these military organizations in protecting national borders.

2.4 Aircrafts Incidents and Accidents in the Special Border Platoons Airfields

In this item, some of the aeronautical events with the 1st/9th Gav, the air unit of the FAB that operates most frequently in the SBP locations, will be analyzed. The item will highlight the importance of Aerospace Infrastructure in good condition for operation at aerodromes in these locations, as the incidents hamper operations and support to SBPs, as well as the cost involved in aircraft repairs, or even their loss.

Bearing in mind the achievement of the aforementioned specific objective, a survey was conducted at the Center for Investigation and Prevention of Accidents (CENIPA), an organ of the Aeronautics structure, responsible for the prevention and investigation of aeronautical accidents, from 16 to 18 July2018. For its realization, the data available in the Flight Safety Management System of CENIPA were accessed as well with information obtained by contact with members of this Center.

The statistics on aeronautical occurrences were sought to allow a comparison between the occurrences verified at the SBP aerodromes and other locations where the 1st/9th GAv operates. Figures 2 and 3 represent the data obtained.

It was verified that, between 2007 and 2018, there were a total of 26 aeronautical occurrences with the C-105 of the 1st/9th Gav. Of these, eleven (42%) took place in the SBP locations that are the target of this study and fifteen (58%) were in other locations.

As a comparison, the frequency of operation was sought from the Air Unit, in terms of flight hours (air effort), considering, in the same way, the defined SBP and other locations. Figure 3 displays these data.

It is noteworthy that only information was found between the years 2011 to 2018, considering that the previous years were registered in another system, with data unavailable at the time of the research.

Of the total annual air effort, the average between the years 2011 and 2018 was 29.92% of hours flown in operation in the defined SBP, with 70.08% remaining for the other locations. From the analysis of Figures 2 and 3, a relevant data is noticed when the occurrences are separated by type.

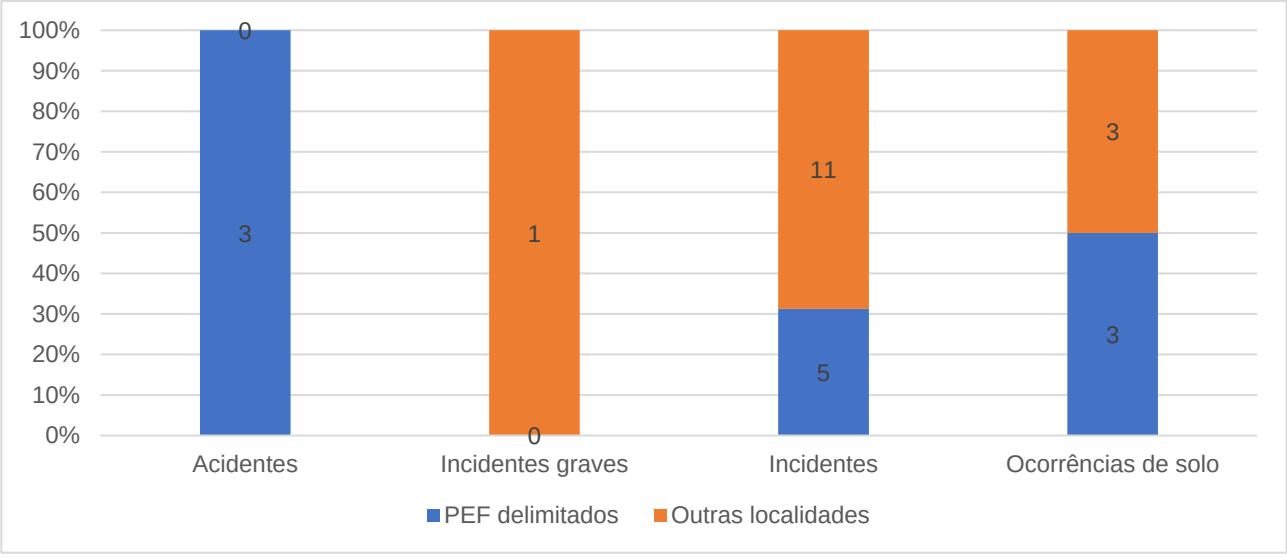

Figure 2 Aeronautical Occurrences - 2007 through 2018.

Source: CENIPA, 2019.

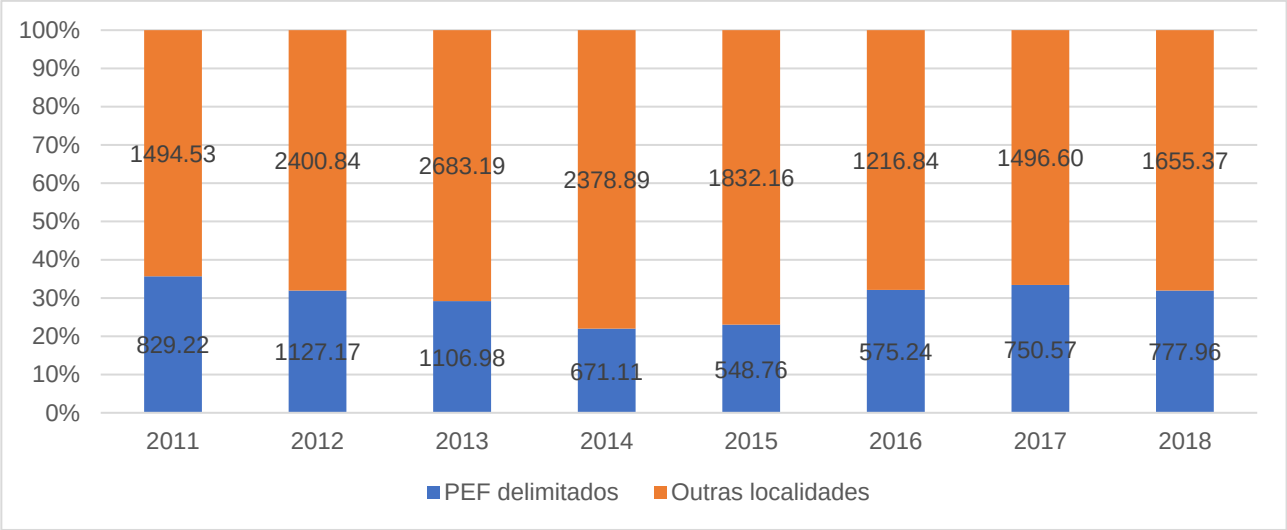

Figure 3 Flight Hours – 1/9 GAv - 2011 Through 2018

Source: 1°/9°GAv.

It was found that 100% of accidents, 31% of incidents and 50% of ground occurrences were in the defined SBP, although the effective operation (in flight hours) did not reach 30%.These data reveal that, in the SBP, the number of events was lower in absolute numbers, but it was higher in percentage terms. It is also inferred that, in the delimited SBP, all the events that produced the most serious consequences (100% of accidents) occurred. The only serious incident recorded in the period, however, occurred in a location outside the defined SBP.

For reasons of confidentiality, the investigation processes on aeronautical events involving military aircraft are considered to be restricted access material, not made public. In this way, only historical facts and statistical data are revealed. Investigations are conducted in order to reveal the factors contributing to the occurrences, with the sole purpose of preventing future occurrences in similar situations.

The occurrence histories, listed below, are literal extracts from the Initial Action Record (RAI)[19] (Cenipa, 2013, p. 13), as written. Information that allowed the identification of the aircraft and the crew was purposely edited and omitted in the case of research, following the recommendations for the dissemination of information about accidents with military aircraft. For classification and type of occurrences, the taxonomy provided for in the CENIPA (Brasil, 2017) standard was followed. The data taken from the RAI are only those necessary for the purpose of this research.

Of the eleven occurrences in the SBP, we now move on to the analysis of the four in which the Aerospace Infrastructure contributed so that there would be an aeronautical occurrence. By observing the history of the occurrences, the seven in which there was no evidence that the Infrastructure contributed to the occurrence were eliminated.

2.4.1 Incident in Surucuru Airfield (SWUQ). May, 26, 2010.

> It was a cargo transport flight from Boa Vista-RR (SBBV) to support the 4th Special Border Platoon, located in Surucucu (SWUQ), in the municipality of Alto Alegre-RR. The Surucucu runway, with dimensions 1,080×30 m, is considered short for the operation of the C-105, requiring the maximum use of the aircraft brakes and the reverses of the engines to make the landing. After touching, during the application of the

[19] RAI Record of factual information collected during the Initial Action carried out at the place of the occurrence. In accordance with the NSCA 3-6 Aeronautics system standard — Investigation of Aeronautical Occurrences with Military Aircraft.

reverse, a "FOD"[20], probably a stone, reached the tip of one of the propeller blades of the right engine[21].

The aircraft has been damaged to one of the right propeller blades. Although the damage was apparently small, around 2 cm × 2 cm, the material could only be repaired by the manufacturer. In this way, the propeller blade was replaced and sent to the company in the United States.

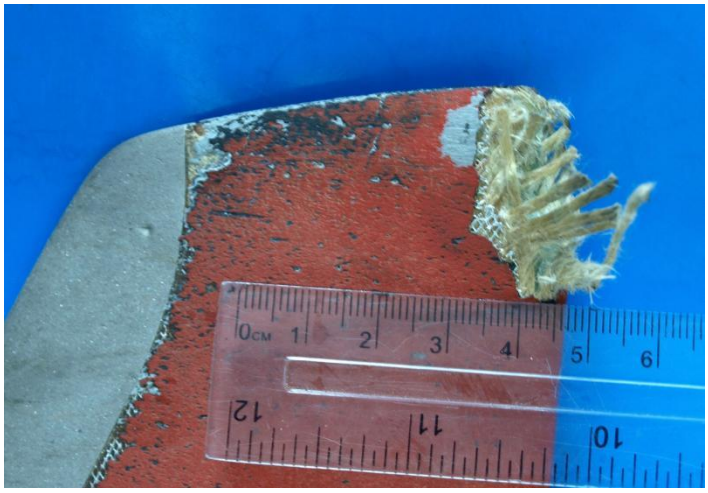

Photo 2 Damaged Propeller

2.4.2 Incident in Querari (SWQE) Airfield, October, 13, 2014.

> The aircraft was fulfilling the PAA mission in the locality of São Gabriel da Cacheira-AM, from where it was taking off to the Brazilian Army's Special Border Platoons in that region. After the last landing made in SWQE, the crew felt the need, during the taxi down the runway, **to deviate from the holes in the center of the runway**. There was a collision of the left wing with the **existing vegetation near the runway**, the aircraft had the acrylic of the navigation light broken and two dented points on the leading edge without prejudice to airworthiness. (Author's bold).

This occurrence is directly related to the Aerospace Infrastructure, in view of the existence of vegetation close to the runway. This became an obstacle mainly when the crew dodged holes along the runway and ended up getting too close with the tip of the wing. The collision, although slight, damaged the aircraft (breakage of the acrylic that protects the navigation light and slight dent in the wing). The incident did not prevent the aircraft from continuing operations.

2.4.3 Accident in Surucucu Airfield (SWUQ), January, 13, 2011.

> The aircraft took off on Jan. 8.2011 bound for Boa Vista, SBBV, and from that location, it would make several "legs" for Surucucu (SWUQ) and Auaris (SWBV), transporting material and supply to CINDACTA IV, Army and COMARA. On the 13th of Jan.2011, in its second landing in Surucucu, transporting support material for COMARA**, the main right landing gear of the plane retracted involuntarily.** The accident occurred around 19: 00Z and the weather conditions were favorable. It was observed that, due to the poor maintenance of the track, **the pilots were operating on the left side, which was the least bumpy side**. (Author's bold).

[20] *Foreign Object Damage*. By generalization, the same name was also given to foreign objects, in the sense that they do not belong to a certain environment.

[21] Italico was used to indicate the excerpts related to the Investigation Reports (RAI).

With the Aerospace Infrastructure as a focus, of the relevant aspects raised and analyzed, it is clear that, at the time, only one side of the runway was used for landing, the one with the least holes, which reduced the dimensions to 1080 m × 15 m. Through Photo 3, there is a wide view of the available width of the track, of the holes in all extension, the elevations nearby the airfield and a part of the unevenness between the runway headlands.

Photo 3 Aerial View of the Final Stop of the Aircraft.
Source: 1°/9° GAv File. Publication Authorized.

2.4.4 Accident in Surucuru Airfield (SWUQ). February, 27, 2016.

> At 12:40 pm (local), the aircraft took off from the Aerodrome of Boa Vista, RR (Atlas Brasil Catanhede - SBBV) bound for the Aerodrome of Surucucu, RR (Alto Alegre - SWUQ), with 06 (six) crew members on board, in order tocarry out the transportation of fuel drums and a passenger. During the final approach to SWUQ headland 30, **the aircraft touched before the runway in use. The main landing gears collapsed and the lower fuselage crashed into the ground.** The aircraft sustained substantial damage [...]. (Author's bold).

The circumstances involved in this accident were similar to what happened in 2011, in the same location, differing only in the extent of the structural damage that was more serious because there was an exit from the runway. Due to the severity of this accident, until the year 2019, the aircraft was still in Surucucu. It had only been towed to the parking lot.

After extensive studies by those responsible for the equipment, it was concluded that the recovery of the aircraft is economically unfeasible. In this way, it will be dismantled and removed gradually"[22]. The spare parts that were in good condition were reused in other aircrafts.

[22] Information obtained in an interview with the Commander of the 1st/9th GAv, through telephone conversation, held in August 2019.

Photo 4 Aerial View of the Accident - Surucucu
Source: 1°/9° GAv File. Publication Authorized.

2.5 Financial Costs of the Accidents and Incidents on the SBP Airfields

The losses resulting from aeronautical events are shown in costs and aircraft unavailability. Costs are expressed in local currency (amounts in foreign currency were converted on the date of occurrence and have not been updated) and the unavailability is expressed in the number of days that the aircraft was unable to fly until the actual repair. The values presented here refer only to the replacement of the damaged item with a new item at the time of the occurrence, not considering the depreciation of the materials over time. Also, labor and personnel transport costs and parts replaced or repaired were not considered. Despite being relevant, they were not available, since the Aeronautics agency in charge of logistics considers these data to be confidential.

In addition to the financial issue, if the aircraft is unavailable for the flight, there are also losses. There were 1,124 days without having an aircraft available. In practice, it can be said that several missions were no longer fulfilled. In addition, an unavailable aircraft overloads the air effort of the others, anticipating scheduled maintenance that would be carried out later. It is perceived that the measurement of material losses resulting from claims is a significant task, as it is important to account for the values and allow comparisons with the costs of refurbishing the aerodromes, installation of equipment to aid navigation, among other factors related to the Aerospace Infrastructure.

Table 4 Cost of Aeronautical Occurrences versus Aircraft Unavailability Days

Occurrence	Cost (US$)	Cost R$	DI	Note:
1	US$62,606.00 ou (	R$116.885,75 (26/05/2010).	2 dias	Maintenance carried out outside the headquarters. Boa Vista - RR
2	US$390,000.00	R$686.010,00 (13/01/2011)	82 dias	Maintenance carried out outside the headquarters. Surucucu.
3	U$9.244,77	R$22.095,00 (13/10/2014)	2 dias	Maintenance performed at headquarters. Manaus - AM
4	US$24,891,666.67 (Custo de uma aeronave C-105).	R$67.207.500,00 (13/01/2005)	1.038 dias	Contract signature date.
	Custo Total em R$	R$ 68.032.490,75		Data not updated.

In this research, a brief comparison was made with some shell-work carried out by the Airports Commission of the Amazon Region (COMARA)[23]. and financed by the Aviation Secretariat (SAC), currently linked to the

[23] COMARA is an Aeronautics body in charge of civil works in the Amazon Region, since the construction or implementation of

Ministry of Infrastructure. The research was limited to the Decentralized Execution Term (TED) No. 2/2017, celebrated in cooperation between SAC and Aeronautics. Table 5 shows the values of the works, according to the Addendum of 08/15/2019, and the value of the acquisition of an aircraft C-105 Amazonas, in this case with the value of the US currency updated for the same date of the celebration of the Additive Term.

Table 5 Comparison Between Aerodrome Works Versus C-105 Acquisition

Location	Cost of work	% compared to C-105
Yauaretê - SBYA	R$ 31.005.739,45	31.2
Estirão do Equador (SWEE)	R$ 34.598.813, 89	34.08
Custo total das obras	R$ 65.604.553,34	66
C-105 Amazonas (custo)	R$ 99.317,01	Prices updated to 08/15/2019.

Looking at Table 2, it can be seen that the cost of a C-105 Amazonas aircraft, operated by 1º/9 GAv, exceeds the sum of the works for two aerodromes in locations with SBP, demonstrating how important maintenance is to maintain the Aerospace Infrastructure in conditions to avoid aeronautical occurrences that end up generating high costs in the replacement of parts of aircrafts or of an aircraft itself. These occurrences still have a negative effect on the availability of the aircraft, compromising the capacity to meet the logistical demands of the Border Platoons and decreasing the capacity of these organizations to fulfill the mission of protecting Brazil's borders.

3. Conclusion

The permanent availability of air assets of the 1st/9th GAv is essential for the air support of the Border Platoons to be carried out and they can fulfill the mission of protecting Brazil’s borders. Therefore, an efficient Aerospace Infrastructure in the Amazon Region is an essential factor for the FAB to fulfill the air transport logistical task. Deficiency in infrastructure, whether in terms of air navigation aids, communication, airstrips and area of an aerodrome can become limiting factors for operations as demonstrated in this article.

The research demonstrated, through the analysis of aeronautical occurrences (accidents/incidents) in the aerodromes of the locations that have Border Platoons, that there is a deficiency in the infrastructure in some aerodromes and, therefore, there was the occurrence of incidents and accidents with aircraft of the Air Unit (1st/9th GAv) that most operates in support of SBP. The data demonstrated not only the importance of supporting border platoons, but also of the infrastructure, whose deficiency often causes considerable losses, including, as a result of one of the events, the complete loss of the aircraft, whose replacement value was almost $ 25 million. The research also showed that the cost of recovering two aerodromes in the area operated by the FAB in support of the SBP was 66% of the value of an aircraft.

Therefore, investment in infrastructure becomes a relevant factor to avoid material losses in terms of spare parts and the aircraft itself. Add to this cost, the availability factor of the aircraft (operational for flight), where in the case of the most serious occurrence, the aircraft was 1,124 days unavailable, causing losses for the missions and overloading the air effort of the other aircraft of the Air Unit. In this particular case, there was a total loss of the aircraft, and it was necessary to replace it to keep the 1st/9th GAv fleet available to meet the planned missions.

The article, in this way, demonstrated the importance of air support so that SBPs can fulfill their mission, as well as an adequate Aerospace Infrastructure that allows not only the planning, but also the execution of the

civil engineering works in this region has a high cost due to the scarcity of labor, inputs and transportation difficulties.

mission in conditions of safety for the crew itself and avoiding material losses, such as that of an aircraft. After all, this support is recognized by SBP members when they highlight it in a succinct but illustrative sentence: “From the first board to the last nail, this platoon was carried on the wings of the Brazilian Air Force”.

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