PROFESSIONAL ARTICLE DOI 10.52781/cmm.e014

Investments in dual-use airport infrastructure, civil and military, in the Amazon region: a proposal of indicators

Inversiones en infraestructura aeroportuaria de doble uso, civil y militar, en la región amazónica: una propuesta de indicadores

Abstract: The airport infrastructure in support of border military units in the Amazon region is of a strategic nature, as it guarantees mobility and, above all, speed to reach the most distant corners of our country. The objective of this assignment is to propose indicators to facilitate decision-making by managers when investing resources in the region's aerodromes. The methodology adopted consisted of collecting information through documentary and bibliographic research. Pavement type data used in several aerodromes, their estimated useful life, as well as the date of completion of the latest interventions allowed us to predict the need for intervention in each location. The number of aeronautical accidents and incidents at each of the researched aerodromes also served as a subsidy for the intervention proposals. Finally, some recommendations were issued to the Army Command in order to improve the development of airport infrastructure in response to Special Border Platoons and increase the security of air operations

Keywords: Logistics. Airport Infrastructure. Amazon. Special Border Platoons. Documentary Research.

Resumen: La infraestructura aeroportuaria en apoyo de las unidades militares fronterizas de la región amazónica tiene un carácter estratégico, asegurando la movilidad y, sobre todo, la velocidad para llegar a los rincones más distantes del país. El objetivo de este trabajo es proponer indicadores que faciliten la toma de decisiones de los gestores a la hora de invertir recursos en los aeródromos de la región. La metodología adoptada consistió en la recolección de información a través de la investigación documental y bibliográfica. Los datos sobre los tipos de pavimentos utilizados en los distintos aeródromos, su vida útil estimada y la fecha de finalización de las últimas intervenciones permitieron predecir la necesidad de intervención en cada localidad. La cantidad de accidentes e incidentes de aviación en los aeródromos estudiados también subvencionó las propuestas de intervención. Por último, se formularon algunas recomendaciones al Mando del Ejército para impulsar el desarrollo de la infraestructura aeroportuaria al servicio de los pelotones fronterizos especiales y aumentar la seguridad de las operaciones aéreas.

Palapras-clave: logística. Infraestructura Aeroportuaria. Amazonia Pelotones fronterizos especiales. Investigación Documental.

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Received: Nov. 05, 2021
Approved: Nov. 29, 2021

COLEÇÃO MEIRA MATTOS
ISSN on-line 2316-4891 / ISSN print 2316-4833
http://ebrevistas.eb.mil.br/index.php/RMM/index

1 Introduction

There are various studies on the Special Border Platoons, as well as on the logistical difficulties inherent to the Amazon environment, but none that address, identify or relate the need for airport infrastructure in favor of its logistical support.

The present study, therefore, aims to propose and apply indicators to classify the localities in the Legal Amazon where the military border units are based, be they Platoons, Detachments or Special Border Companies, in order to establish the appropriate priorities in the application of investments in airport infrastructure, considering, for this purpose, their dual use, civil and military, since these military border organizations are usually based in localities, towns or small cities, with which they share the use of aerodromes.

It should be remembered that, according to the Strategic Conception Air Force 100, the operation of National Air Mail is part of the particular subsidiary tasks of Aeronautics, highlighting the carrying out of national integration missions, "aimed at serving less developed localities or regions, difficult to access and devoid of other means of transport", in order to "alleviate the suffering of the most needy populations, assisting them with the possible means of accelerating their development towards full citizenship" (BRASIL, 2018b, p. 19).

It should also be noted that there are units that do not have the support of an airstrip, or that cannot be reached by road, such as the Vila Brasil Detachments, in the state of Amapá, and São Salvador, in Acre.

There are also the Platoons of Epitaciolândia and Plácido de Castro, both subordinate to the Border Command of Acre / 4th BIS, which do not have the support of an aerodrome, but, on the other hand, are supplied by roads.

All these localities were also analyzed in order to compose the proposed priority classification list.

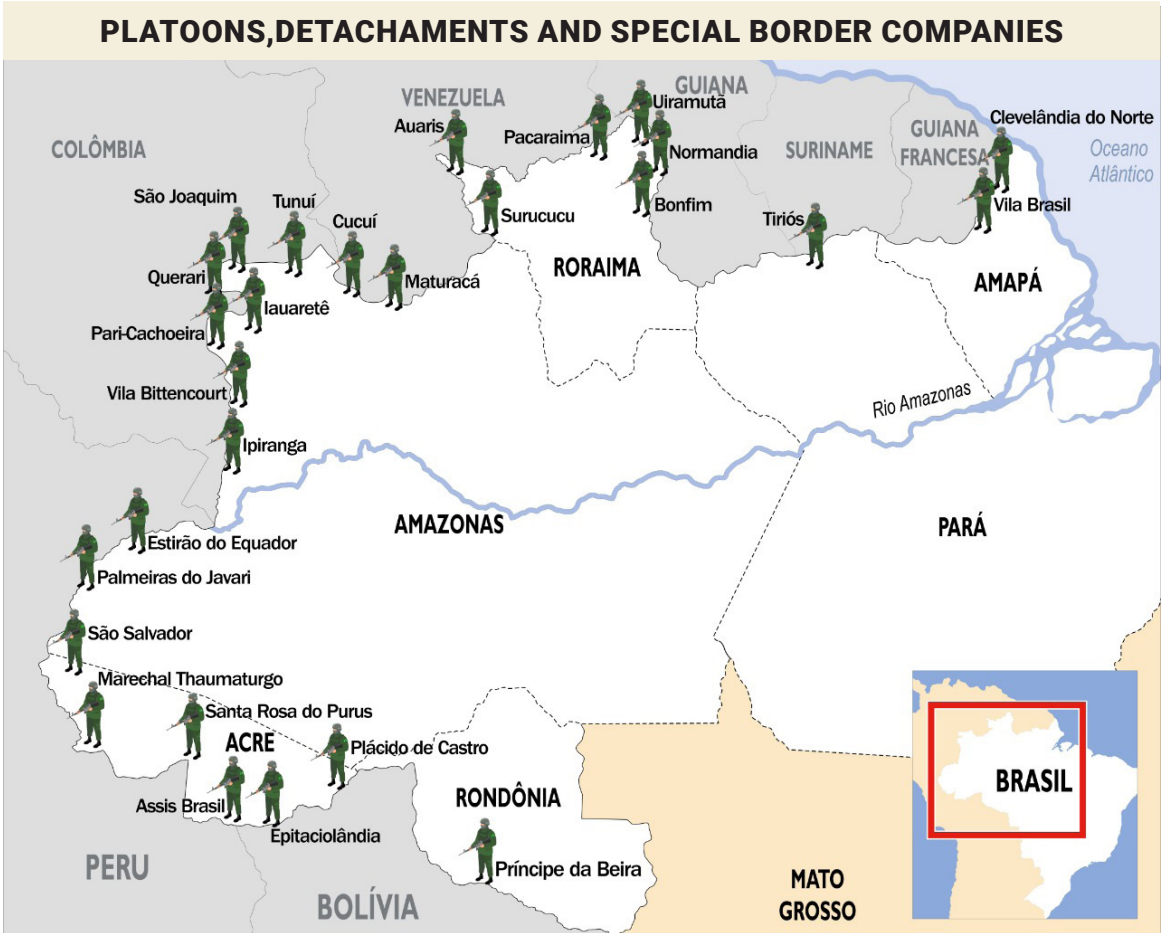
Initially, a documentary search was carried out in order to collect data regarding the location of each PEF/DEF/CEF, as well as the logistical factors used in its resupply.

Also the object of this study was the data collection of accidents and aviation incidents occurred in these locations since 2010, where the airport infrastructure has been a contributing factor for the occurrence of the accident.

Finally, taking into account that these military units act as drivers of development and help to secure people in the region, as well as the possibility of raising resources from the National Civil Aviation Fund for investment in this airport infrastructure, it is important to highlight that there is a civil population around each PEF/DEF/CEF, as well as, in most cases, indigenous people served by FUNAI, who would also benefit from the execution of these works.

It is important to emphasize that these aerodromes are important parts of the transport network that serves the Amazon region, not necessarily because of their volume of traffic or the number of passengers transported, but, in some situations, because they are the main ways of connecting these military organizations and the communities that live in their surroundings with the rest of the country. Without them functioning, it is impossible to carry out aeromedical evacuations or even maintain the availability of health services offered by the Special Secretariat of Indigenous Health (SESAI) through the Indigenous Special Sanitary District (DSEI) operating in the Amazon region (BRASIL, 2021b).

Figure 1 – Location of border units in the Amazon.



Source: Elaborated by F. Lisboa of the Amazon Region Airports Commission (2021).[1]

1 Figures 1 and 2 were produced by Sd F. Lisboa, from the effective of COMARA, exclusively for this article.

2 Methodology

There are some maxims in the corporate world that cannot be ignored, whether in a private institution or a public body, civil or military. Kaoru Ishikawa, a Japanese engineer and business administration theorist, stated that "only what is measured is managed" (FALCONI, 2013, p. 3).

As we learn in school benches and especially in everyday practice, economics is a science that deals with scarce resources and unlimited needs. It becomes essential, therefore, to establish indicators for each process, so that the manager can make the best decisions when distributing budget.

How to define, however, the priorities when it comes to directing your resources? The greater importance of one locality over another seems somewhat ethereal, but "intangible elements that seem impossible to assess can be measured" (HUBBARD, 2015, p. 5).

Although there is a vast bibliographic source when it comes to Border Special Platoons (FRANCHI, 2013; MIRANDA, 2012; RODRIGUES, 2004; SILVA, 2007), few numerical data related to airport infrastructure could be extracted from this specialized literature.

Other researchers, such as Sant'anna (1998) and Théry (2005), have looked at the modes of transport available in the Amazon, as well as their development opportunities, but their focus has been directed to the waterway and road modes.

In this sense, there was an investigation in other sources, such as the National Civil Aviation Agency; responsible for the registration and approval of aerodromes in Brazil; the Department of Airspace Control, responsible for updating the Auxiliary Publication of Air Routes (ROTAER); the Aeronautical Accidents Investigation and Prevention Center (CENIPA); as well as the Amazon Region Airports Commission (COMARA) to search for data such as: registration status of aerodromes; types of airstrip pavements; history of aeronautical accidents and incidents at aerodromes that serve the PEF, in which the airport infrastructure has been a contributing factor; history of interventions carried out in the airport infrastructure of these locations, among others considered relevant.

In addition to presenting and proposing a series of possible indicators, it was also necessary to prioritize them.

After collecting and analyzing the available data, a case study was carried out in one of the most critical tracks currently in operation and which constitutes the only access route for the resupply of the 4th PEF, subordinated to the Roraima Border Command, located in Surucucu, in the municipality of Alto Alegre-RR.

Finally, recommendations were issued, some of which could be implemented immediately and others that could, if deemed appropriate, be adopted in the medium or long term.

3 Data Collection

There is a plethora of data that could be used to classify aerodromes according to precedence to receive investments, in order to meet civilian and military needs.

Some indicators are intuitive, for example, the available modes of transport and the travel time to get to the locality. If the only option to access the region is the air modal, this PEF, due to its isolation, will receive a higher priority.

What to say, however, about the river and land modals? At first glance, one would think that the PEF served by roads would be last in the order of priority, but what if the road conditions are so poor that the travel time is longer than that spent on river navigation?

The heavy rains of the period known as the Amazon winter often make it impossible or, at least, greatly hinder traffic for several months, as occurs, for example, in BR-156, which connects the cities of Macapá and Oiapoque, in the state of Amapá.

Another emblematic example is the BR-307, which connects the city of São Gapriel da Cachoeira to the District of Cucuí, in the state of Amazonas, in the region of the triple border between Brazil, Colombia and Venezuela. Although the road distance is only 202 km, the resupply of the Cucuí PEF is made by the river modal, in a journey of 36 hours in a vessel regionally called "bongo", because the road is practically impassable by vehicles that do not have four-wheel drive, still missing a bridge on arrival at the locality, which forces to unload the cargo and transport it in small boats from the final stretch to the barracks.

Security in airport operations seems to be another essential factor in setting priorities. In lay eyes, the simple fact that an airstrip is open to operations would indicate the guarantee of minimum safety requirements, but, unfortunately, this is not the Amazon reality.

The state of conservation of the runway, the possible presence of obstacles in its surroundings, the existence of dumps nearby, which constitute hotspots of attraction of birds, among other problems, compromise the operability of the aerodrome, and may culminate in the cancellation of its approval by of the National Civil Aviation Agency (ANAC).

The non-approval of an aerodrome makes it impossible for natural or legal persons to use it, as it constitutes an infringement provided for in the Brazilian Aeronautics Code (art. 302, item VI, letter f: "use airfield without regulatory conditions of use") (BRASIL, 1986, n.p.), in addition to leaving an eventual operator overdrawn from the insurance guarantee in case of an accident.

Therefore, due to the lack of available data, such as the state of conservation of the lanes according to the PCI method (Pavement Condition Index); the presence of obstacles in the surroundings of the aerodrome, such as trees violating the surfaces of the protection zone; the lack of operational fencing, which allows the entry of animals into the aerodrome in critical phases such as landing and take-off; it was decided to start surveying aeronautical accidents and incidents that occurred on these runways between 2010 and 2020.

Another data used, according to the history of works carried out by COMARA, was the date of completion of the interventions and their respective forecast of durability, depending on the type of pavement adopted.

At first, the logistical flow executed by the Brazilian Army in supplying each of the 27 PEF/DEF/CEF existing in the Amazon region was mapped.

Basically, it can be said that the 8th Military Region (RM), based in Belém-PA, supplies the PEF/DEF/CEF of the states of Pará and Amapá, and that the 12th RM, located in Manaus-AM, does the same for the units of the states of Amazonas, Roraima, Acre and Rondônia.

According to Ferreira and Franchi (2020), the 12th RM has the support of other military organizations of the Brazilian Army located in Manaus, such as the Amazon Military Command Boat Center (CECMA) and the 12th Supply Battalion (12th BSup). The 12th RM is also responsible for coordinating the employment of Brazilian Air Force (FAB) transport aircraft through the Amazon Support Plan (PAA). In exceptional cases, helicopters of the 4th Army Aviation Battalion (4th BAvEx) are employed in this activity of supplying border units.

In the case of the Amapá Border Command / 34th BIS, the only unit studied here supported by the 8th RM, there is a sui generis situation that occurred in the resupply of the Vila Brasil Detachment.

Vila Brasil is about 102 km from the CEF of Clevelândia do Norte, by river, upstream of the Oiapoque River. Despite the distance being relatively close, the displacement by means of small boats called "voadeiras" takes approximately 5 hours to go and 4 hours to return.

This 102 km stretch, also known as Médio Oiapoque, is distinguished from other sections of its course by having greater current and closing the largest steps, where its most remarkable waterfalls and rapids unfold.

According to MORAES, we can notice "large muddy stretches, sometimes forming complicated systems: maze of islands, islets, channels and rapids that riot before rock outcrops distributed in dikes, rounded blocks and flagstones" (MORAES, 1964, p. 5).

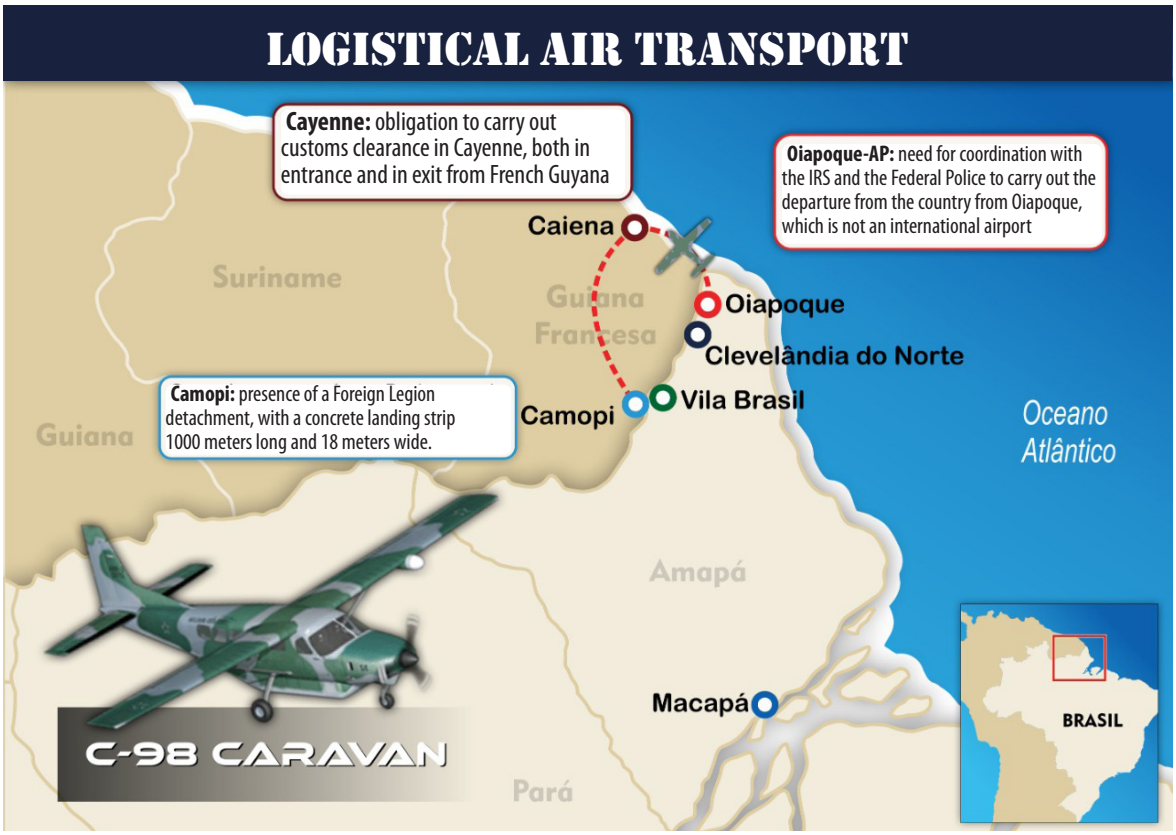
Altogether, there are 11 waterfalls that need to be completed when traveling between Clevelândia do Norte and Vila Brasil. Some of them, such as the Rochelle Waterfall, require all personnel, material and the vessels themselves to be overflowed. In others, such as Caxiri, depending on the water level, it is only necessary to disembark the personnel so that the boatman can cross it.

The most interesting thing, however, is that while Brazilians face a huge challenge and expose themselves to high risks in waters often infested with sucurijus and poraquês, to carry out a simple resupply of their troops, on the other side of the river, facing the DEF of Vila Brasil, in French overseas territory, in a village called Camopi, there is a Detachment of the Foreign Legion, equipped with a concrete airstrip, 1000 meters long by 18 meters wide.

FAB, through a considerable effort of coordination of the Brazilian Army with the Ministries of Defense and Foreign Affairs, managed to carry out some resupply missions for the DEF of Vila Brasil in 2019 using, for this purpose, this Camopi track.

However, the obligation to carry out customs clearance in Cayenne, both at entry and exit from French Guiana, significantly increased the stretch to be flown, from 97 km (Oiapoque-Camopi) to 307 km (Oiapoque-Cayenne-Camopi), raising costs and reducing the availability of cargo to be transported.

Figure 2 – Resupply of the Vila Brasil Detachment by air



Source: Elaborated by F. Lisboa of the Amazon Region Airports Commission (2021).

Another additional need for coordination with the revenue and federal police involved the authorization to leave the country from Oiapoque, because if the International Airport of Macapá was used, the volume transported in each mission would be derisory.

The cooperation of the French government was not enough, there was still the need for authorization to fly over foreign military aircraft, which requires a minimum of seven days in advance, and the shipment of all the cargo transported in the flying boats to cross the Oiapoque river again at the border back to Brazil.

Regardless of the difficulties involved in transportation, the logistics data were raised with the commanders of the 4th, 5th, 6th, 7th, 8th, 34th and 61st Jungle Infantry Battalions and will be analyzed in the following chapter.

4 Results Analysis

The first analysis performed with the collected data involved only the modals employed in the resupply of each border unit, as well as the time spent in this logistics operation.

In general, the classification of localities in this pre-analysis followed a fairly simple logic:

1) The units were ordered, in descending order, according to the time of dis-placement by the terrestrial modal. Locations not served by roads received a zero travel time, making them last priority.

2) Then there was a new arrangement, this turn of the time of travel by river, also in descending order. This reordering received priority over land travel time, but still left last priority to the locations served exclusively by the air modal.

3) Next, we proceeded to order according to the flight time spent of C-98 (Cara-van), from the longest flight time to the smallest, from the headquarters of the Battalion, or, in the case of the 6th BIS / Cmdo Fron Rondônia, from Porto Velho, which caused new changes in the orders made in Items 1 and 2.

4) Once the orders were completed, according to the time of displacement in the various modes, priority was given to those localities that had more restricted resupply options. This way, the locations that effectively use the air modal in its resupply were prioritized, first of all.

5) The penultimate selection criterion adopted consisted in verifying which lo-calities are resupplied by means of the fluvial modal, since there are several rivers that have watery stretches and, therefore, are not used as a logistic route. The localities not served by the waterway were prioritized.

6) Finally, the criterion of verifying which localities use the terrestrial modal in their resupply was adopted. The locations not served by this modal were prior-itized.

The results of this preliminary analysis, at first glance, seem reasonable, but because of its simplicity, it contains a number of distortions that will be discussed and resolved later, by including new variables.

Table 1 – Pre-classification of military border units, according to the modes of transport used and the time of travel..

OM	BORDER UNIT	LOCATION	Travel time (h)		
			Aerial	Fluvial	Terrestrial
Cmdo Fron Amapá / 34º BIS (Macapá-AP)	1º PEF	Tiriós (Óbidos-PA)	02:05	0	0
Cmdo Fron Roraima / 7º BIS (Boa Vista-RR)	5º PEF	Auaris (Amajari-RR)	01:35	0	0
Cmdo Fron Rio Negro / 5º BIS (São Gapriel da Cachoeira-AM)	2º PEF	Querari (São Gapriel da Cachoeira-AM)	01:15	0	0
Cmdo Fron Roraima / 7º BIS (Boa Vista-RR)	4º PEF	Surucucu (Alto Alegre-RR)	01:10	0	0
Cmdo Fron Rio Negro / 5º BIS (São Gapriel da Cachoeira-AM)	3º PEF	São Joaquim (São Gapriel da Cachoeira-AM)	01:10	0	0
Cmdo Fron Acre / 4º BIS (Rio Branco-AC)	4º PEF	Santa Rosa do Purus-AC	01:00	292	0
Cmdo Fron Solimões / 8º BIS (Tabatinga-AM)	1º PEF	Palmeiras do Javari (Atalaia do Norte-AM)	01:10	192	0
Cmdo Fron Solimões / 8º BIS (Tabatinga-AM)	3º PEF	Vila Bittencourt (Japurá-AM)	01:10	120	0
Cmdo Fron Rio Negro / 5º BIS (São Gapriel da Cachoeira-AM)	6º PEF	Pari-Cachoeira (São Gapriel da Cachoeira-AM)	01:05	48	0
Cmdo Fron Rio Negro / 5º BIS (São Gapriel da Cachoeira-AM)	1º PEF	Iauaretê (São Gapriel da Cachoeira-AM)	00:55	12	0
Cmdo Fron Rio Negro / 5º BIS (São Gapriel da Cachoeira-AM)	7º PEF	Tunuí (São Gapriel da Cachoeira-AM)	00:45	48	0
Cmdo Fron Solimões / 8º BIS (Tabatinga-AM)	4º PEF	Estirão do Equador (Atalaia do Norte-AM)	00:40	72	0
Cmdo Fron Solimões / 8º BIS (Tabatinga-AM)	2º PEF	Ipiranga (Santo Antônio do Içá-AM)	00:35	120	0
Cmdo Fron Juruá/ 61º BIS (Cruzeiro do Sul-AC)	DEF	Marechal Thaumaturgo-AC	00:35	72	0
Cmdo Fron Rio Negro / 5º BIS (São Gapriel da Cachoeira-AM)	4º PEF	Cucuí (São Gapriel da Cachoeira-AM)	00:35	24	0

OM	BORDER UNIT	LOCATION	Travel time (h)		
			Aerial	Fluvial	Terrestrial
Cmdo Fron Rio Negro / 5º BIS (São Gapriel da Cachoeira-AM)	5º PEF	Maturacá (Santa Isabel do Rio Negro-AM)	00:30	14	0
Cmdo Fron Juruá/ 61º BIS (Cruzeiro do Sul-AC)	DEF	São Salvador (Mâncio Lima-AC)	-	24	0
Cmdo Fron Amapá/ 34º BIS (Macapá-AP)	DEF	Vila Brasil (Oiapoque-AP)	-	5	0
Cmdo Fron Amapá/ 34º BIS (Macapá-AP)	1ª CEF	Clevelândia do Norte (Oiapoque-AP)	01:30	0	14
Cmdo Fron Rondônia / 6º BIS (Guajará Mirim-RO)	1º PEF	Príncipe da Beira (Costa Marques-RO)	01:25	12	11
Cmdo Fron Roraima / 7º BIS (Boa Vista-RR)	6º PEF	Uiramutã-RR	00:45	0	6,5
Cmdo Fron Acre / 4º BIS (Rio Branco-AC)	2º PEF	Assis Brasil-AC	00:45	0	5,5
Cmdo Fron Roraima / 7º BIS (Boa Vista-RR)	3º PEF	Pacaraima-RR (Marco BV-8)	00:40	0	5
Cmdo Fron Roraima / 7º BIS (Boa Vista-RR)	2º PEF	Normandia-RR	00:35	0	3
Cmdo Fron Roraima / 7º BIS (Boa Vista-RR)	1º PEF	Bonfim-RR	00:25	0	2
Cmdo Fron Acre / 4º BIS (Rio Branco-AC)	CEF / 1º PEF	Epitaciolândia-AC	-	0	3,5
Cmdo Fron Acre / 4º BIS (Rio Branco-AC)	3º PEF	Plácido de Castro-AC	-	0	2

Source: The author (2021).

The first distortion that can be observed in the table above refers to the PEF of Santa Rosa do Purus, 6th placed in the ranking of priorities. Although it is possible to resupply the Platoon by means of the river modal, using, first, the BR-364, from Rio Branco to Manoel Urbano, in a 4-hour journey, and then climbing the Purus River, in another 12 days of travel, this route is not usually used, except in exceptional situations for the transport of large volumes of material, as has been the case adopted by the 7th BEC in the year 2021 for the reconstruction of the aerodrome.

The second distortion comes from Marechal Thaumaturgo, 14th placed in the ranking, a locality endowed with airport infrastructure, but in such a precarious state that FAB ceased to operate at the aerodrome a few years ago and ANAC itself excluded it from the aerodrome register, according to Ordinance no. 3480, of November 26, 2020 (AGÊNCIA NACIONAL DE AVIAÇÃO CIVIL, 2020).

São Salvador and Vila Brasil appear, respectively, in the 17th and 18th positions, although they are not equipped with aerodromes that allow their supply. In the case of Vila Brasil, this need is relatively well explained by the interministerial effort expended in order to allow FAB to use the Camopi aerodrome in French Guiana, as reported in Chapter 3 of this work.

Consideration must also be given to the question of the interventions carried out in recent years at these aerodromes. Estirão do Ecuador, for example, ranked 12th in priorities for receiving investments, should have its airstrip completed in 2021. Because it is being made entirely of concrete, it is estimated to last approximately 50 years for this infrastructure.

Except for the performance of small periodic maintenance, such as the revitalization of horizontal signage, the replacement of sealant between the concrete slabs, the sealing of any cracks that may arise, among others of smaller magnitude, there is no talk of greater investments in Estirão do Equador before the year 2071, which is why this aerodrome would no longer have higher priority.

Based on the premise that there are various types of pavement in aerodromes that meet the PEF/DEF/CEF, the following maximum useful life parameters were adopted, according to the adaptation of the specialized literature (MACEDO, 2005)::

- Portland Cement Concrete (PCC): 50 years
- Hot Mix Asphalt (HMA): 20 years
- Double Bituminous Surface Treatment (DBST): 10 years
- Single Bituminous Surface Treatment (SBST): 10 years
- Soil, Gravel, Lateritic Concretion or Grass: 5 years

The maximum service life of fill dirt, gravel, bank gravel or grass tracks was estimated at half the service life of surface treatments, due to the absence of data on the durability of these types of coatings.

The data of the year of completion of each of the works of implantation or recovery of the aerodrome were collected in order to be able to estimate the need for intervention. In cases where it was not possible to determine the year of completion, the year 2021 was adopted in order to avoid unnecessary allocations of resources.

In this case, the same six steps adopted earlier were repeated, with the only difference being that, after Step 3, the classification, in ascending order, of the need for intervention was included. The localities that do not have an aerodrome (São Salvador, Vila Brasil, Epitaciolândia and Plácido de Castro) were canceled in this regard.

Tiriós, for example, which was in the 1st place of the ranking, due to the fact that it had the longest flight time to reach the PEF, having no other modes of transport than air, had its asphalt runway (CBUQ) enlarged and recovered in 2009.

Considering, therefore, a maximum useful life of 20 years, no further interventions will be necessary in that locality before 2029, which is why Tiriós ceases to have the highest priority.

Iauaretê, which is currently under construction and is expected to be completed in 2023, with its runway being entirely rebuilt in concrete, will not require further care until 2073, and should therefore lose priority.

Investigating the accidents and aviation incidents that occurred in these locations, where infrastructure has been a contributing factor, it is realized that there is a need to devote greater priority to aerodromes where operating conditions have become marginal, to the point of endangering the safety of air operations and, consequently, human lives.

Two apparent exceptions to the rule were the incidents that occurred in Vila Bittencourt and Ipiranga in 2011, in which the main tire burst at the time of landing. Because there was no major damage, these incidents were not investigated and, consequently, do not have a final report. However, it can be assumed that the airport infrastructure was not a contributing factor, since both runways had been rebuilt in concrete in the year 2008.

Thus, these two incidents were disregarded in order not to unduly interfere in the use of this variable.

Even with the adoption of these new variables (need for intervention, accidents and aeronautical incidents), the Detachments of São Salvador and Vila Brasil remained with low priority, because there was no criterion that prioritizes locations not served by aerodromes.

Therefore, there was a need to inform the feasibility of using the air modal for the resupply of these DEF, as well as to estimate a period for the start of the works, equivalent to the need for intervention for already consolidated aerodromes

Table 2 – Classification of border military units, according to priority for receiving investments in airport infrastructure.

Prior.	Location	Travel time (h)			Type of airstrip floor*	Intervention Need	Accidents and Incidents
		Aéreo	Fluvial	Terrestrial			
1	Surucucu	01:10	0	0	SBST	2021	7
2	Querari	01:15	0	0	DBST	2007	2
3	São Joaquim	01:10	0	0	DBST	2000	0
4	Auaris	01:35	0	0	DBST	2009	0
5	Santa Rosa do Purus	01:00	292	0	DBST	2021	0
6	Tiriós	02:05	0	0	HMA	2029	0
7	Pari-Cachoeira	01:05	48	0	SOIL	1994	1
8	Cucuí	00:35	24	0	DBST	1998	0
9	Maturacá	00:30	14	0	DBST	2008	0
10	Tunuí	00:45	48	0	SOIL	2010	0
11	Marechal Thaumaturgo	00:35	72	0	GRVL	2026	0

Prior.	Location	Travel time (h)			Type of airstrip floor*	Intervention Need	Accidents and Incidents
		Aéreo	Fluvial	Terrestrial			
12	São Salvador	-	24	0	-	2050	-
13	Vila Brasil	-	5	0	-	2053	-
14	Vila Bittencourt	01:10	120	0	CONC	2058	1
15	Ipiranga	00:35	120	0	CONC	2058	1
16	Palmeiras do Javari	01:10	192	0	CONC	2062	0
17	Estirão do Equador	00:40	72	0	CONC	2071	0
18	Iauaretê	00:55	12	0	CONC	2073	0
19	Bonfim	00:25	0	2	LC	2026	1
20	Pacaraima	00:40	0	5	HMA	2009	0
21	Assis Brasil	00:45	0	5,5	HMA	2023	0
22	Príncipe da Beira	01:25	12	11	GRASS	2026	0
23	Uiramutã	00:45	0	6,5	LC	2026	0
24	Normandia	00:35	0	3	SOIL	2026	0
25	Clevelândia do Norte	01:30	0	14	HMA	2028	0
26	Epitaciolândia	-	0	3,5	-	-	-
27	Plácido de Castro	-	0	2	-	-	-

Source: The author (2021).

Note: HMA (Asphalt); CONC (Concrete); GRASS (Grass); GRVL (Gravel); LC (Lateritic Concretion); DBST (Double Bituminous Surface Treatment); SBST (Single Bituminous Surface Treatment).

The amount of aviation accidents and incidents that occurred in Surucucu between the years 2010 and 2020 arouses attention and, in a way, justifies the occupation of the first place in the proposed new ranking of investments.

To better understand the situation of this aerodrome, we will conduct a case study with some data collected locally.

5 Case Study

On February 27, 2016, around 1:30 pm, local time, the FAB 2808 aircraft, a C-105 Amazonas, when making the approach to Runway 30 of SWUQ (Surucucu), touched off before the threshold, causing the retraction of the main landing gear, with the consequent exit to the right of the runway limits.

Figure 3 – FAB 2808 accident in SWUQ

Source: Marcelo Marques, G1 RR.

As a result, the Aeronautical Accidents Investigation and Prevention Center (CENIPA) recommended that the operation of this type of aircraft at the aerodrome of Surucucu be suspended until further studies are carried out regarding the operation of the C-105 in that locality, or until procedures are established that eliminate or at least mitigate the effects of the risks involved.

There are few options to get to Surucucu. Roads do not exist. The Mucajaí River, the closest to the site, has quite intense rapids, which restrict the navigation of larger vessels. Its waters do not bathe the Special Border Platoon based there, because about five kilometers in the middle of the forest separate them.

According to the Air Routes Manual (ROTAER), the local runway, code ICAO SWUQ, is 1080 meters long by 30 meters wide, with asphalt coating (BRASIL, 2021a).

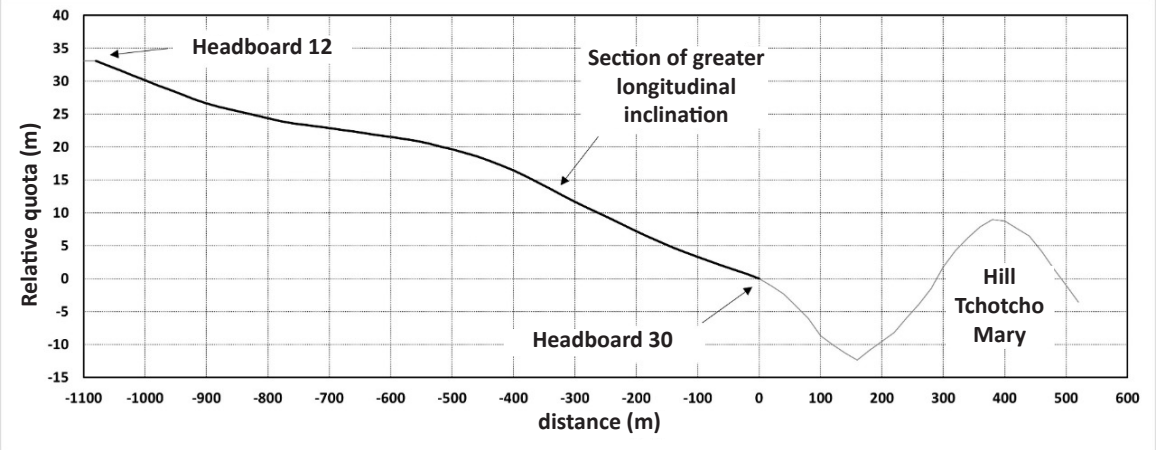
What ROTAER does not report is that the longitudinal slope of the surucucu runway exceeds the maximum tolerance allowed by the Brazilian Civil Aviation Regulation (RBAC) 154, which is 2% where the runway code number is 1 or 2, as is the case in question (AGÊNCIA NACIONAL DE AVIAÇÃO CIVIL, 2019).

In the case of Surucucu, the maximum unevenness on the axis of the airstrip (PPD) is 33.09 meters, which gives us a longitudinal slope of 3.06%.

However, the same RBAC 154, in its Appendix G, item G.4 (a) (2), informs that the longitudinal slope along any stretch of a PPD, should not exceed 2% where the code number is 1 or 2.

Information obtained through the Technical Report of Topographic Survey nº RR004.52-NC.RT001, from August 2019, point out that, despite the slope of the runway as a whole being 3.06%, there are even more critical stretches, such as those ranging from 300 to 350 meters, starting from headland 30, where the slope exceeds twice the maximum allowed, reaching 4.95% (BRASIL, 2019).

Graph 1 – Longitudinal profile of the Surucucu airstrip.



Source: The author (2021).

In addition to this condition, which is quite critical, there is still a hill near the head of head 30, called "Tchotcho Mary", that violates the approach ramp, inducing the pilots to approach in a steeper trajectory than recommended.

Due to the characteristics of the relief and the slope gradient of the runway, all landings are carried out in the direction of the headboard 30 and all takeoffs use the headboard 12.

Runways with a length of less than or equal to 1,500 meters are considered short for the C-105 and, to operate under these conditions, there are some specific procedures such as: reduction of the maximum operating weight, stabilized approach, lower ramp than normal and maximum use of the brakes and the reverse of the engines during landing, among others.

The lower than normal ramp is used to favor the touch at the beginning of the runway and to make the most of its extension for the braking of the aircraft, also contributing to the maintenance of a lower descent ratio.

The presence of a hill near the head of the runway in Surucucu induces pilots to vary the descent ratio, making it difficult to maintain a fully stabilized approach.

The maximum use of the brakes and the reverse, in turn, contributes to the breakdown of the asphalt layer, which, in the case of Surucucu, is only a simple surface treatment.

The operating conditions of the runway, associated with the type of pavement, cause the need for constant interventions, which, in turn, promote more and more undulations and irregularities in the runway, decreasing the rolling comfort, generating additional efforts in the landing gear of the aircraft and, consequently, impairing braking.

The last major intervention in Surucucu was carried out by the Amazon Region Airports Commission (COMARA) in 2011, when there was the collection of the right main landing gear of a C-105 in the locality and the replacement of the entire runway surface was carried out, due to the existence of numerous holes that caused the detachment of fragments.

The machines and implements used by COMARA in this work can still be seen in Surucucu, such as vibrating rollers, wheel tractors, a track tractor, a loader, a grader, among others.

The logistical difficulties of transport impose such high costs that, in this case, it does not justify the removal of the equipment, which may be demanded again in the foreseeable future.

Between 2016 and 2019, a period in which the operations of the C-105 in Surucucu were discontinued, the Brazilian Air Force, through the Institute for Research and Tests in Flight (IPEV) and the Institute for Development and Industrial Coordination (IFI), prepared and approved a specific operational supplement for the operation of the C-105 in SWUQ.

With the flight profile of this supplement, the São José dos Campos Aeronautics Computing Center (CCA-SJ) developed a virtual simulation environment to enable the training of the C-105 crews.

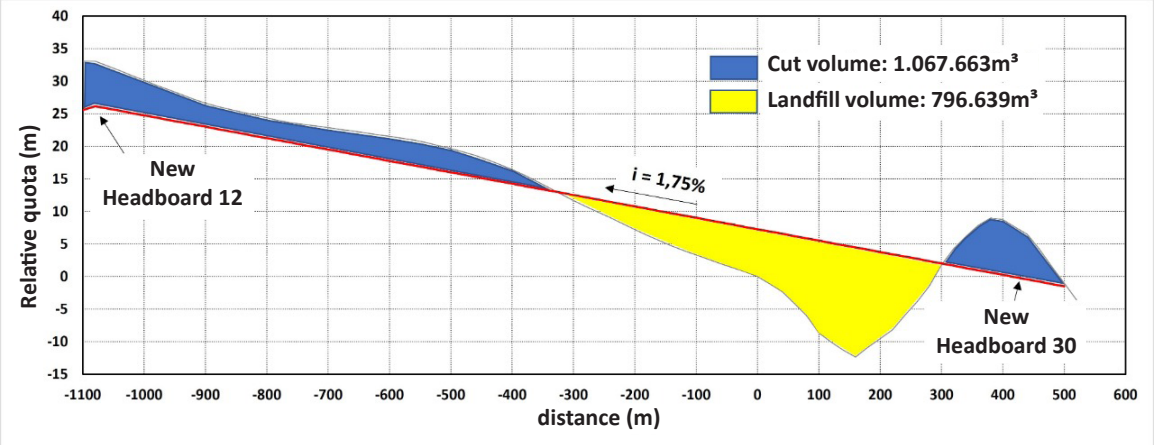
At the same time, the Airspace Control Department (DECEA), with the support of COMARA, installed in Surucucu an equipment called APAPI, or Simplified Precision Approach Trajectory Indicator, in order to provide pilots with visual indications of the ideal approach ramp for landing.

All these initiatives have certainly mitigated the risks involved from the operation of the C-105 in Surucucu, which, despite of complex and with higher risk than a conventional takeoff and landing operation, it was considered feasible in a context of special operation with known and controlled risk.

As the risks have not been eliminated, it is considered highly desirable, if there is budgetary availability, to promote new investments in airport infrastructure, since the longitudinal slope of the PPD remains above the maximum 2% provided for in RBAC 154.

The proposal for Surucucu, therefore, goes in the direction of carrying out a large-scale intervention, correcting the longitudinal slope, so as to lower it to values less than 2%, and, at the same time, extend it from the current 1080 to 1500 meters in length.

Graph 2 – SWUQ longitudinal slope correction proposal.



Source: The author (2019).

The intention, as can be seen from the analysis of the figure above, is to make two cuts on the ground: one at the highest part of the track, reducing the height of headboard 12 by approximately 7.5 meters, and another at the summit of the Tchotcho Mary hill, which would become part of the track. In parallel, land the area between the headboard 30 and the hill, at a maximum height of 16.8 meters.

The cutting volume is slightly higher than the landfill, and the average transport distance of the material to be excavated is less than one kilometer.

The two greatest difficulties envisaged fall, first of all, on the transport of large equipment to Surucucu, as well as on the channeling of a 300-meter stretch of the Surucucu creek, which passes between the headboard 30 of the track and the Tchotcho Mary hill.

In 2011, COMARA dismantled larger machines, such as a motor grader, whose total weight was 14,371 kg, to transport it from Boa Vista by C-105 to Surucucu. It took four trips of C-105, as well as a Blackhawk transfer to take the cabin of the grader as an external cargo, due to the fact that its dimensions did not allow boarding in the internal compartment of the C-105.

This time, however, the proposal is to acquire specific equipment for the Surucucu project, such as excavators and bucket trucks, in such a way that the company that won the bid delivers the equipment already disassembled, in dimensions compatible with the load capacity of the C-105 or the Blackhawk, and reassemble them when they reach Surucucu, leaving FAB solely responsible for transporting the various components.

A boundary condition to be adopted during a work of this magnitude in Surucucu is that the runway continues to allow the operation of smaller aircraft, such as the C-98 Caravan, since this will continue to be the only way to access the locality.

As the C-98 operates at its maximum load capacity on lanes measuring 750 meters in length, even unpaved, this boundary condition does not impose insurmountable limitations on the execution of the work.

Another important factor to be taken into account during the executive planning for this work refers to the volume of material to be transported, since air support will be fundamental and the required amount of flight hours will not be negligible. The estimated flight hours, therefore, should not only be part of the project, but also be approved by the General Staff of the Air Force in order to guarantee full compliance

6 Recommendations

6.1 Aerodrome administration

According to the Auxiliary Publication of Air Routes (ROTAER), the aerodrome administrator is the "authority responsible for the administration of the aerodrome and the proper functioning of the maneuver area" (BRASIL, 2021a, p. 0.4-10).

ROTAER brings only information regarding the administrators of public aerodromes and helipads, which can be the State Government, INFRAERO, an Aeroclub, among others. The absence of any indication in that publication means that the public aerodrome or helipad is administered by the city hall.

But with regard to the use of the aerodrome, in addition to public, it can also be classified, according to the same ROTAER, in:

> **MIL** – Military: aerodrome intended, in principle, for the use of military aircraft.
> **PRIV** – Private: civil aerodrome, built in an area of private property, for the use of its owner, whose commercial exploitation is prohibited, and can only be used with the owner's permission.
> **PRIV/PUB** – Private aerodrome open to public traffic.
> **PUB** – Public: civil aerodrome, intended for aircraft traffic in general.
> **PUB/MIL** – Public aerodrome that has military installations of the Air Force Command.
> **PUB/REST** – Restricted Public: civil aerodrome, built in an area of public property, for use reserved to the public agency that has it under its jurisdiction, whose commercial exploitation is prohibited, and can only be used with authorization from the respective public agency (BRASIL, 2021a , p. 0.4-4, emphasis added).

Of the 27 Special Border Platoons and Detachments currently operating in the Amazon region, only four do not have an airstrip in their vicinity.

Of the 23 existing aerodromes, therefore, only two are public, Ipiranga and Clevelândia do Norte, managed, respectively, by the municipal governments of Santo Antônio do Içá-AM and Oiapoque-AP; four are military, Tiriós, Príncipe da Beira, Estirão do Ecuador and Iauaretê, administered by the Belém Air Base, the second by the Brazilian Army and the last two by COMARA; ten are private, nine managed by FUNAI: São Joaquim, Cucuí, Querari, Pari-Cachoeira, Maturacá, Vila Bittencourt, Palmeiras do Javari, Auaris and Surucucu, and one administered by the Department of

Highways of Acre (DERACRE): Santa Rosa do Purus; and seven lost their approval, for not having complied with ANAC's requirements, five being administered by the municipal governments where they are located: Uiramutã, Bonfim, Normandia, Pacaraima and Tunuí, and two administered by DERACRE: Marechal Thaumaturgo and Assis Brasil.

Practically a third of these 23 aerodromes had their homologations revoked by the National Civil Aviation Agency (ANAC), due to the existence of non-conformities not remedied by the administrator, being excluded, therefore, from the register of aerodromes.

Once excluded from the register, the aerodrome, in thesis, is closed to air traffic. The operation of civil aircraft to support and complement the logistical effort in service to the PEF makes this activity, therefore, irregular, constituting an infringement provided for in the Brazilian Aeronautics code, in addition to subjecting the operator to non-insurance coverage in case of a possible accident or incident.

Another interesting detail concerns the fundraising of the National Civil Aviation Fund (FNAC) to invest in these aerodromes. One of the essential conditions for the aerodrome to be able to receive resources from FNAC is that it be included in the ANAC aerodrome register as a public type aerodrome.

The aerodromes managed by FUNAI are all private, as the entity is characterized by being a public foundation that has legal personality under private law.

In this sense, it is recommended that the Brazilian Army carry out management to take over the administration of the aerodromes that meet the PEF, classifying them as public type, in order to guarantee their homologation conditions, as well as to make it possible to raise funds from the FNAC via formalization of decentralized execution terms with the National Secretariat of Civil Aviation.

6.2 Anemometric stations

When it comes to the deployment of a pioneer runway, one of the main concerns of the designer refers to the orientation of the runways, since they must be aligned with the direction of the prevailing winds.

How to determine, however, this direction?

The students of Professor Wolney Ramos Ribeiro, who taught Earthmoving at the Aeronautics Institute of Technology (ITA) between 1977 and 2003, and who had previously accumulated 20 years of experience building airstrips in the Amazon region, used to hear picturesque stories about the empirical methods adopted in determining the direction of the wind.

From the 1950s to the 1970s, the prevailing wind was determined by observing an eventual inclination of the trees or even consulting the local indigenous populations, according to Professor Wolney.

The situation today, however, is completely different. Although it is no longer so common to implement pioneer runways, even though there is still a demand for it, ICAO Annex 14, which deals with the Aerodrome Project, recommends that wind data (direction and speed) be collected for a minimum period of five years, with no fewer than eight daily obser-

vations spaced equally in time, ie every three hours (INTERNATIONAL CIVIL AVIATION ORGANIZATION, 2016, p 3-2).

This data collection occurs through the deployment of an anemometer or an anemograph, installed at a height of 10.0 meters from the ground (±1.0 m), in an area free from the effects of air disturbances caused by nearby objects, as recommended in the Aeronautics Command Manual dealing with the Installation of Surface and Altitude Meteorological Stations (BRASIL, 2018a).

To better clarify what would be an area free of objects in the vicinity, the same Manual directs that the towers of the anemometers keep the minimum horizontal distance of ten times the height of the obstacles existing in the surroundings of the tower (BRASIL, 2018a).

Considering, therefore, a relatively flat terrain, in a forest area, with trees reaching the maximum height of 20 meters, the ideal would be that a circular clearing, of 200 meters of radius, would be opened in order that the anemometric station would be installed in the center of this circle.

Finally, it is recommended that management be carried out for the installation of anemometric stations in the geometric center of the areas where new airstrips are intended to be deployed, such as Vila Brasil-AP, São Salvador-AC and any other localities not provided with airport infrastructure, but where the Brazilian Army intends to deploy a PEF in the future.

6.3 Maintenance of aerodromes

Some aviation accidents and incidents would be easily avoided if simple aerodrome maintenance measures were adopted.

On October 13, 2014, for example, the pilot of a C-105 Amazonas aircraft, after landing in Querari, tried to dodge holes in the center of the runway and ended up touching the tip of the left wing in bushes existing on the side of the runway.

Although the damage was slight – just the breakage of the navigation light acrylic –, this episode is classified as an aeronautical incident and could have had more serious consequences, including taking the aircraft out of operation.

Another incident, this time in Surucucu on May 26, 2010, also involved a Casa C-105 aircraft and originated from the presence of a foreign object present on the airstrip.

After landing, during the reverse application, a rock hit the tip of one of the aircraft's right propeller blades. The damage, once again, was slight, but it involved replacing this blade.

Loose stones along the runway, or any other objects unduly present in the operational environment of the aerodrome, which have the ability to cause damage to aircraft, shall be characterised as FOD (*Foreign Object Damage*) and must be eliminated.

One of the practices adopted in aerodromes managed by the Brazilian Air Force consists of tasks of the "Search FOD" type, when the unit's personnel are positioned in a profiled

manner along the width of the runway and aircraft parking lot and walk from one end to the other, collecting all loose objects (especially stones) that could cause damage to the aircraft.

The recommendation, therefore, is that the personnel of the PEF carry out a weekly "Search FOD" or at least on the eve of the PAA aircraft landing.

In addition to searching the FOD and the removal of trees and bushes on the sides of the runway and in the approach and take-off areas, another recommendation, for aerodromes that have fences around the operational area, is that the access gates be kept closed to avoid the inadvertent entry of animals and that a periodic inspection be carried out on the perimeter of the aerodrome, in order to verify and guarantee the integrity of the fence

6.4 Pavement management system

The lack of an adequate pavement management system for the aerodromes that meet the PEF prevents preventive maintenance from being scheduled on these airstrips. Interventions are usually performed when the pavements are in critical condition, therefore requiring heavier interventions such as restorations or even the complete reconstruction of the runway (CORDOVIL, 2010, p. 17).

The Brazilian Air Force addressed this need in 2003, when the first version of ICA 85-10 was published, which deals with the implementation of an Aerodrome Management systematic within the scope of the Air Force Command (BRASIL, 2017).

Annually, the Air Force Command issues a report on the state of conservation of the network of airport pavements under its administration, seeking a rational prioritization of the investments necessary for the conservation and rehabilitation of these pavements.

By means of periodic monitoring, which in the case of the runways that support the PEF, due to their low air traffic, could be done every three years, it would be possible to raise data indicating the condition of the pavements, that is, numbers that express the structural, functional, aesthetic and security aspects of the airport infrastructure.

This way, it would be easier to offer the appropriate support to decisions regarding the establishment of effective and economic strategies to provide and maintain, over time, a network of pavements in operational conditions.

It is therefore recommended that the Brazilian Army adopt an airport pavement management system in order to monitor the state of the airstrips that serve the border units, proposing the appropriate interventions at the most appropriate times

6.5 PDAIM update

The Air Force Command has a Plan for the Development of Aerodrome of Military Interest, better known by the acronym PDAIM, whose last update dates from 2005.

According to that publication, aerodromes of military interest are all those aerodromes, whether civilian, shared or military, capable of supporting civil or military aircraft engaged in actions of military interest (BRASIL, 2005).

Among the various criteria for selecting aerodromes of military interest, there are those that are of interest to the Brazilian Navy and Brazilian Army commands.

Most of the municipalities where the border units are located are contemplated in the aforementioned plan. However, due to the activation of new Detachments, after the publication of the last edition of the PDAIM, it is recommended, by the Brazilian Army, to carry out efforts to include in the PDAIM other locations that it deems of interest, such as Vila Brasil, in the municipality of Oiapoque-AP.

In addition to the inclusion of new areas of interest, it is also recommended to carry out management so that each aerodrome is equipped with an aircraft parking yard with minimum dimensions of 130×80 meters, in order to allow the simultaneous and unrestricted operation of two KC-390 aircraft.

7 Conclusion

The present work proposed to present and apply a series of indicators to classify the aerodromes in the Legal Amazon that serve dual civil and indigenous communities, as well as border military organizations, be they Platoons, Detachments or Special Border Companies, in order to establish the appropriate priorities in the application of investments in airport infrastructure for the benefit of the country.

As we have seen, there is a fruitful debate about the limitations and opportunities for improvement in the various modes of transport in the Amazon region (SANT'ANNA, 1998; THÉRY, 2005).

The data used in the logistical supply of each location were collected according to the different modes available, whether by land, river or air.

Those locations that had more restricted resupply options and that were located farther from their distribution centers received due priority.

The information regarding the types of pavements used in each of the aerodromes objects of this study, their estimated useful life, as well as the date of completion of the last major interventions in each locality served as a subsidy for a proposal of new interventions in a time horizon for the next 50 years.

In this order, Surucucu, Querari, São Joaquim and Auaris were the tracks that received the highest priorities and therefore deserve special attention from the authorities involved.

The first of them, Surucucu, as it was the scene of two accidents and five aeronautical incidents in the last decade, was the subject of a case study, which pointed out the need to rebuild the runway, with the proper correction of its longitudinal slope.

Some recommendations were issued in order to promote the development of airport infrastructure in service to military border units, as well as increase the safety of air operations in these locations.

The first of these concerns the assumption, by the Brazilian Army, of the administration of the aerodromes that serve the PEF, the surrounding population and any indigenous communities, in order to guarantee their approval conditions, as well as to make it possible to raise funds from the FNAC for their maintenance.

The second recommendation is to carry out management for the installation of anemometric stations in areas where new airstrips are intended to be deployed, in order to collect wind data, for a minimum period of five years, in order to define the best direction of the runway axis.

The third recommendation is a very simple procedure to be implemented, but one that will bring greater safety to air operations at these aerodromes, such as the periodic collection of debris on the runway surface, the removal of trees and bushes on the sides of the runway and in the approach and take-off areas, as well as keeping the access gates to the operational area closed, in order to prevent the inadvertent entry of animals.

The fourth and penultimate recommendation refers to the possibility of adopting an airport pavement management system, with the aim of monitoring the state of conservation of the airstrips that serve the border units, proposing the appropriate interventions at the most opportune moments.

Finally, it is recommended that the Brazilian Army take steps to include the Vila Brasil runway (to be built) in the Development Plan for Aerodrome of Military Interest, as well as to propose the expansion of the aircraft parking aprons to the minimum dimensions of 130×80 meters, aiming at the simultaneous and unrestricted operation of two KC-390 aircraft.

Due to the lack of data available on the state of conservation of the lanes according to the PCI method (Pavement Condition Index) and the presence of obstacles in the surroundings of the aerodrome, an opportunity to improve this work is glimpsed from the survey of this information by technical teams, including surveyors and airport pavement specialists.

These recommendations, if well planned and financed, can be transformed into actions with expressive dual results, both for the defense sector and for the support and quality of life of communities along the Brazilian border, as they would promote better operating conditions for civil and military aviation.

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