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## A Case Study of Airport Sustainability in Legal Amazon

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# 1. INTRODUCTION

## 1.1. Main topic of research

Brazil is a country of continental proportions and with great cultural, social, and economic diversity. The Brazilian State must seek the development of all its regions to promote and stimulate development, providing opportunities for sustainable growth in a harmonized manner throughout the Brazilian territory.

The integration of any given place to the rest of the society is one of the most important aspects of its development, and each place has specific needs regarding connectivity and the necessary infrastructure.

The Amazon Region, with all its forest, rivers, and soil typology, has very particular characteristics, being one of the regions with the greatest difficulty of access and, consequently, lack of development, being considered one of the most isolated regions in the world, with low economic power, but with a high interested worldwide in some areas and demands of integration.

The absence of roads, and in some cases the impossibility to build them, leaves only two connection possibilities: fluvial navigation and air transportation.

The first option, although very important to residents, isn't enough to promote the development of the area, either fulfill society's needs, since in some cases reaching the closest cities takes more than a week on a boat.

On the other hand, for the development of air transportation, the existence of airports infrastructure is indispensable, and over decades the development of such infrastructure hasn't reached society's needs.

Several communities should have been integrated with the rest of the country but aren't. It is known that the development of airports in that region has the potential to not only facilitate the transport of people and goods to regions of difficult access, but it is also a way of connecting local populations to the national market and even to the economy at a global level.

The Brazilian State has already invested a lot of resources with the construction of a series of airports in the region, however, for various reasons, such as bad management, lack of technical knowledge, the politicization of the management and the competition of scarce resources from city halls with other demands of municipalities, the infrastructure deteriorated over time and did not fulfill the needs for safe and efficient aviation evolution. This, beyond the low operational volume at airports in the Amazon, tends to make the airports economically unfeasible, affecting the connectivity and accessibility to these airports, consequently leading airlines to lose interest in operating in those places, leaving several cities unattended and inhibiting economic growth in the region.

Given this scenario, the need for integration, and the intrinsic characteristics of this region and its population, this study assesses the challenges and alternatives for the creation and management of a network of sustainable airports in the Legal Amazon region, with a specific focus on airports in the State Amazonas, proposing the use of advanced technologies for remote controlling and a better and more efficient administration to allow the accessibility and feasibility of air operations, connecting areas of difficult access and stimulate the growth and development of local economies.

## 1.2. Practical problem

The Legal Amazon is an area of more than 5 million square kilometers, corresponding to 61% of the Brazilian territory, instituted by the Brazilian Government to plan and promote the social and economic development of the states of the Amazon region, which historically share the same economic, political and social challenges.

Even though the development of airports in the Legal Amazon is a latent demand of the Brazilian population, there have not yet been significant advances due to the lack of planning and integration of the involved stakeholders' actions.

The problem regarding the lack of airport infrastructure at amazon region is long know and have been object of study from IPEA (Institute of Applied Economic Research), which has proposed the installation of a Basic Network of Transport from Amazon, but it failed to propose solutions to make the airports economically feasible.

In isolated regions, due to the difficulty of integration and connectivity with large centers, it is difficult to find service providers, especially the more specialized ones, as the most qualified professionals do not have long-term incentives to settle in these locations. As an example, we can mention the provision of air navigation assistance services in remote regions, where traffic controllers do not settle in small cities and, in addition, the low volume of operations would not economically justify the necessary incentive to retain these professionals in these locations.

The alignment of these two elements has encouraged some companies to develop remote operations solutions to overcome this barrier that impeded sustainable development and the integration of isolated regions. Operation centers were created in larger cities, capable of providing the quality of life for these professionals, and in the remote region a technology system was implemented consisting basically of cameras and other meteorological equipment that bring information from the remotely operated region.

There are international experiences in this field, such as Sweden's experience in operating remote-control towers(R-TWR) and Japanese experience in operating remote air flight services (R-AFIS). In Brazil, we can mention some initiatives such as the pilot project for the implementation of remote TWR in the Santa Cruz Air Base/RJ, the R-AFIS of Fernando de Noronha Airport operated remotely from CINDACTA III in Recife/PE and the implementation of automatic surface meteorologic stations (EMS-A) that provide meteorological data through VHF broadcasting directly to pilots and transmitted to the International Bank of OPMET messages of type METAR AUTO and SPECI AUTO, without human intervention.

Since 5th round of concessions, Brazilian government actions shows that one possibility to create economically feasible airports is the adoption of public-private partnership, with the concession of airports in blocks, where more profitable airports will compensate for deficit ones.

Another initiative, still in the initial stage of studies, refers to the partnership concession model (PPP – Partnership Public-Private), with the concession of public services for the expansion, maintenance and operation of airport infrastructure to private management, in order to improve the infrastructure and management of airports Parintins, Carauari, Coari, Eirunepé, São Gabriel da Cachoeira, Barcelos, Lábrea and Maués, all located in the State of Amazonas.

In this sense, this work intends to investigate whether it is possible to integrate the management and operation activities, for a group of small regional airports located in the State of Amazonas, seeking to point out scenarios and solutions that allow the connection of these models, and thus the operational viability of these airports.

### 1.3. Main objective

This study explores possible solutions to promote the sustainable development of a group of small airports located in the State of Amazonas using integrated management, maintenance and operation processes, as well as the use of remote technologies that allow the monitoring and decision-making of these processes centrally, resulting in an efficient and sustainable management model.

In this sense, it is intended to identify probable integrated management models applicable to the reality of this group of airports, as well as technological solutions that allow the reduction of operational costs and at the same time allowing operations to take place in compliance with regulatory requirements.

### 1.4. Structure of the document

This study is organized in another four sections.

In the Methods section of this study, detailed information will be presented on the methodology used to analyze the problem, the data sources, and how this information was collected.

Later, in the Results section, this study will present detailed information on the results achieved in the analyses, presenting suggestions for improvement actions based on technological advances available to improve the management of the airport infrastructure and proposals for a management model in blocks to enable the sustainability and promote operational safety, security, and accessibility of airports.

In the Discussion section, we will present the selected State of Amazonas Airports block, assess its current situation and propose some possible actions for the economically viable development of such airports, based on two main points: improving efficiency through the adoption of operating technology remote and advanced administration methods, based on block administration using specialized administration.

Finally, the conclusion section will present the main possible remedies to be used for the sustainable development of airports in the State of Amazonas, the limitations of the analysis of this study and suggestions for continuing the study of the subject.

## 2. METHODS

### 2.1. Research Design

This document is a case study focused on small regional airports in the State of Amazonas and aims to generate an in-depth and multifaceted understanding of the reasons for the underdevelopment of these airports, analyzing the subsequent developments on airport concessions concerning the concession on blocks of airports and evaluating experiences on remote control and operation of some air navigation services, both in Brazil and especially abroad.

We will also explore the successful experience of the use of command-and-control centers during large events held in Brazil, FIFA World Soccer Cup and Olympic Games, where various services were provided at a centralized post, optimizing the management and integration of complex systems.

Possibilities of economic subsidies and partnership mechanisms by the Government for the exploitation of these aerodromes will also be evaluated, such as concessions and private public partnerships, as well as direct administration by the Union through its public company: Infraero.

Through it, we intend to understand the issues related to infrastructure development and management of small airports in the State of Amazonas and, at the same time, present possible solutions for the promotion and sustainable development of a group of airports as the final product of the study.

### 2.2. Data collection

Due to the complexity of access and the need to integrate the Legal Amazon, some institutions developed research with the objective of diagnosing the demands and needs of the region's infrastructure. The IPEA was identified as one of the sources of data on the State of Amazon transport network. It is also worth mentioning the State Airports Plan, which is macro-director document for the integrated planning of air transport and airport infrastructure of state interest. This will allow the understanding of the evolution of airport infrastructure and investment plans, making it possible to understand the current scenario on the State of Amazonas.

In search of technological solutions to be applied to aim at efficiency and reduction of operating costs and to make the operation viable in a sustainable manner, examples of applications in remote air navigation services were found. The Japanese State presented a working paper at the 39th International Civil Aviation Organization (ICAO) assembly on its experience in providing AFIS services remotely. Sweden, through the company SAAB, implemented the remote-control tower solution in several airports, enabling the provision of navigation assistance in a control center hundreds of kilometers away.

Projects and initiatives such as airport concessions, private public partnerships and integrated management of operations, maintenance and administration existing in the Brazilian scenario, even if applied to other modals or systems, were used as reference and adapted to the subject of study.

Information regarding current situation of the airports will be obtained from ANAC's oversight reports, where information regarding the necessary investments and enhancements is available.

## 2.3. Data analysis

Initially we will present a diagnosis of airport infrastructure on the State of Amazonas, identifying the entity responsible for the administration and operation of these airports, highlighting the reasons for current situation and proposing alternatives for a better use of the available resources and attract necessary investments.

Next, we will evaluate systems and models of management and provision of remote information in civil aviation existing in Brazil and abroad.

Finally, we will evaluate the block of airports management model, that could provide the operational and administrative efficiency, needed for airports' sustainability, either with the direct support of the Federal Government or with the support of the private sector.

There will be no field data collection, so all the information presented on this paper is obtained from available documents, some of which are the result of local or remote oversighting, resulted from ANAC'S oversighting plan.

## 3 Results

### 3.1 Definition of the airports to be analyzed - Case Study

The State of Amazonas has currently 22 public aerodromes, open to commercial operations, and 40 private aerodromes, that can only be used with owner permission, distributed over 1,571,000 km<sup>2</sup> which results in an insignificant availability rate of aerodromes per km<sup>2</sup>.

According to table 2 below, from the 22 public aerodromes, 7 are administered by the State Government, 12 by the Municipalities and 3 by Brazilian Airport Infrastructure Company (Infraero), that were granted to private initiative in the 6th round of concessions.

In terms of infrastructure, most of the aerodromes are operating in VFR conditions, the runway is built with a layer of asphalt surface and with runway width compatible with most of the aircrafts that operate commercial flights in Brazil. But, in terms of ACN/PCN value, we can observe on the Table 1 that in some aerodromes (in general, small airports) the pavement may not have adequate capacity for commercial operations 121 in the short term.

Currently, the aerodromes of Itacoatira, São Paulo de Olivença, Fonte Boa and Apuí face restriction measures due to non-conformities identified by ANAC oversight.

Table 1 – list of public aerodromes – State of Amazonas

ICAO CD	NAME	COUNTY	FLIGHT RULES	RWY LENGTH	WIDTH	ACN/PCN	SURF	AERODROME OPERATOR
SBEG	EDUARDO GOMES	MANAUS	VFR Day/Night e IFR Day/Night	2700 m	45 m	PCN 71/F/C/X/T	Asfalto	INFRAERO
SBIC	ITACOATIARA	ITACOATIARA	VFR Day e IFR Day	1515 m	30 m	PCN 8/F/C/Y/U	Asfalto	MUNICÍPIO
SBMY	MANICORÉ	MANICORÉ	VFR Day	1265 m	30 m	PCN 12/F/C/Y/U	Asfalto	ESTADO
SBTF	TEFÉ	TEFÉ	VFR Day/Night e IFR Day/Night	2200 m	45 m	PCN 29/F/C/X/U	Asfalto	INFRAERO
SBTB	TABATINGA	TABATINGA	VFR Day/Night e IFR Day/Night	2150 m	32 m	PCN 34/F/A/X/T	Asfalto	INFRAERO
SBUA	SÃO GABRIEL DA CACHOEIRA	SÃO GABRIEL DA CACHOEIRA	VFR Day e IFR Day	2600 m	45 m	PCN 47/F/C/X/U	Asfalto	MUNICÍPIO
SDCG	SENADORA EUNICE MICHILES	SÃO PAULO DE OLIVENÇA	VFR Day	1200 m	23 m	PCN 6/R/B/Y/T	Concreto	MUNICÍPIO
SWBC	BARCELOS	BARCELOS	VFR Day	1200 m	30 m	PCN 6/F/B/Y/U	Asfalto	ESTADO
SWBR	BORBA	BORBA	VFR Day	1200 m	30 m	PCN 8/F/C/Y/U	Asfalto	MUNICÍPIO
SWCA	CARAUARI	CARAUARI	VFR Day	1665 m	18 m	PCN 12/F/C/Y/T	Asfalto	ESTADO
SWEI	EIRUNEPÉ	EIRUNEPÉ	VFR Day	2300 m	45 m	PCN 30/F/C/X/U	Asfalto	MUNICÍPIO
SWFN	FLORES	MANAUS	VFR Day	799 m	30 m	5700 kg / 0,5 MPa	Asfalto	ESTADO
SWHT	FRANCISCO CORREA DA CRUZ	HUMAITÁ	VFR Day	1200 m	45 m	PCN 7/F/B/Y/U	Terra	MUNICÍPIO
SWII	IPIRANGA	SANTO ANTÔNIO DO IÇÁ	VFR Day	1500 m	30 m	PCN 13/R/C/W/U	Concreto	MUNICÍPIO
SWKO	COARI	COARI	VFR Day	1600 m	36 m	PCN 29/F/C/X/U	Asfalto	MUNICÍPIO
SWLB	LÁBREA	LÁBREA	VFR Day	1200 m	30 m	PCN 7/F/C/Y/U	Asfalto	ESTADO
SWMW	MAUÉS	MAUÉS	VFR Day	1200 m	30 m	PCN 8/F/C/Y/U	Asfalto	ESTADO
SWNK	NOVO CAMPO	BOCA DO ACRE	VFR Day	1600 m	30 m	PCN 19/F/C/Y/U	Asfalto	MUNICÍPIO
SWOB	FONTE BOA	FONTE BOA	VFR Day	1270 m	27 m	PCN 6/F/C/Y/U	Asfalto	ESTADO
SWPI	PARINTINS	PARINTINS	VFR Day/Night	1800 m	30 m	PCN 33/F/B/X/T	Asfalto	MUNICÍPIO
SWTP	SANTA ISABEL DO RIO NEGRO	SANTA ISABEL DO RIO NEGRO	VFR Day	1200 m	30 m	PCN 8/F/C/Y/U	Asfalto	MUNICÍPIO
SWYN	APUÍ	APUÍ	VFR Day	1200 m	23 m	PCN 12/F/B/Y/U	Asfalto	MUNICÍPIO

The proposed model will be the sponsored concession (PPP), with the concession of public services for the expansion, maintenance and operation of the airport infrastructure to private management, with a view to correcting infrastructure and management deficiencies that hinder the proper provision of services airports. This concession is under study phase, with the hiring of a consulting company to elaborate a Technical, Economic and Environmental Feasibility Studies.

### 3.2 Airports Concessions

According to BNDES (2019), until the 80s, air transport in Brazil was highly protected by regulation, with fixed ticket prices, and there was practically no competition between companies. The scenario began to change in the 90s with the adoption of incentives for competition in the aviation sector that continued throughout the 2000s, reaching the liberalization of tickets prices in 2001 and the creation of the National Civil Aviation Agency (ANAC), the Brazilian Civil Aviation Authority, in 2005.

These incentives, combined with the growth of the Brazilian Gross Domestic Product (GDP) and the social rise of lower classes in the country, resulted in an increase in demand for air transport and, consequently, the entrance of new airlines and finally a decrease in ticket prices.

Between 2004 and 2011, passenger movements at Brazilian airports grew at a rate of approximately 15% per year, putting pressure on the airport infrastructure that was operated mostly by Federal or State Governments. As an example, the Brazilian Airport Infrastructure Company (Infraero), a federal government-owned company that operated 67 airports at that time, was facing difficulties in carrying out works and recurring frustration with planned investments. Around 2010, 13 of the 20 largest Brazilian airports had operational restrictions due to limitations in the airport apron and/or passenger terminals, and the situation was also expected to worsen due to the prospect of further GDP growth and the major events to come (World Cup 2014 and Olympics 2016) (ANAC, 2021).

Given the need to make large investments and the fiscal limitations of the Public Power, the airport concession process proved to be an option that could also take advantage of a possible efficiency gain with the participation of the Private Sector. The São Gonçalo do Amarante Airport, a new airport to meet the demand near the city of Natal – RN, was chosen as a pilot project to test the concession model before expanding it to others Brazilian airports.

The concession was carried out in 2011 and, subsequently, more airports were granted in rounds, considering the relevance and criticality of the situation of the airports in terms of saturation. In the first four rounds, the airports were granted individually, but as of the 5th Round, the concessions started to be made through regional blocks. A resume of the concession program can be found on the Table 2:

*Table 2 - Round of Brazilian Airports Concession*

1st Round	2011	São Gonçalo do Amarante Airport (near Natal – RN)
2nd Round	2012	Airports of Guarulhos (São Paulo – SP), Viracopos (Campinas – SP), and Brasília - DF
3rd Round	2014	Airports of Confins (near Belo Horizonte – MG) and Galeão (Rio de Janeiro – RJ)
4th Round	2017	Airports of Florianópolis – SC, Fortaleza – CE, Porto Alegre – RS and Salvador – BA
5th Round	2019	Northeast Block: Airports of Recife – PE, Maceió – AL, João Pessoa – PB, Aracaju – SE, Juazeiro do Norte – CE and Campina Grande – PB
		Midwestern Block: Airports of Cuiabá – MT, Sinop – MT, Rondonópolis – MT, Alta Floresta – MT and Barra do Garças – MT
		Southeast Block: Airports of Vitória – ES e Macaé – RJ
6th Round	2021	South Block: Airports of Curitiba – PR, Foz do Iguaçu – PR, Londrina – PR, Bacacheri (região de Curitiba – PR), Navegantes – SC, Joinville – SC, Pelotas – RS, Uruguaiana – RS and Bagé – RS
		Central Block: Airports of Goiânia – GO, Palmas – TO, Teresina – PI, Petrolina – PE, São Luís – MA and Imperatriz – MA
		North Block I: Airports of Manaus – AM, Tabatinga – AM, Tefé – AM, Rio Branco – AC, Cruzeiro do Sul – AC, Porto Velho – RN and Boa Vista – RR
7th Round	2022	Block RJ/MG: Airports of Santos Dumont - Rio de Janeiro/RJ, Aeroporto Ten. Cel. Aviador César Bombonato - Uberlândia/MG, Mário Ribeiro - Montes Claros/MG, Mario de Almeida Franco - Uberaba/MG e Jacarepaguá - Roberto Marinho – Rio de Janeiro/RJ

	<p>Block North II: Airports of Belém - Val de Cans - Júlio Cezar Ribeiro -Belém/PA and Alberto Alcolumbre - Macapá/AP</p> <p>Block SP/MS/PA: Airports of Congonhas - São Paulo/SP, Campo Grande - Campo Grande/MS; Campo de Marte - São Paulo/SP; Corumbá - Corumbá/MS ; Ponta Porã - Ponta Porã/MS ; Maestro Wilson Fonseca - Santarém/PA ; João Corrêa da Rocha - Marabá/PA; Carajás - Parauapebas/PA; and Altamira - Altamira/PA .</p>
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According to ANAC (2021), the airport concession aims to attract investments to expand and improve the Brazilian airport infrastructure, promoting improvements in passenger services and defining service quality levels based on international standards. According to the most recent satisfaction survey carried out by the National Civil Aviation Secretariat of the Brazilian Ministry of Infrastructure (SAC/Minfra), overall passenger satisfaction increased from 3.86 to 4.40 between 2013 and 2020, and the positive assessment of airports increased from 69% to 92% in the same period, indicating the success of the concession rounds.

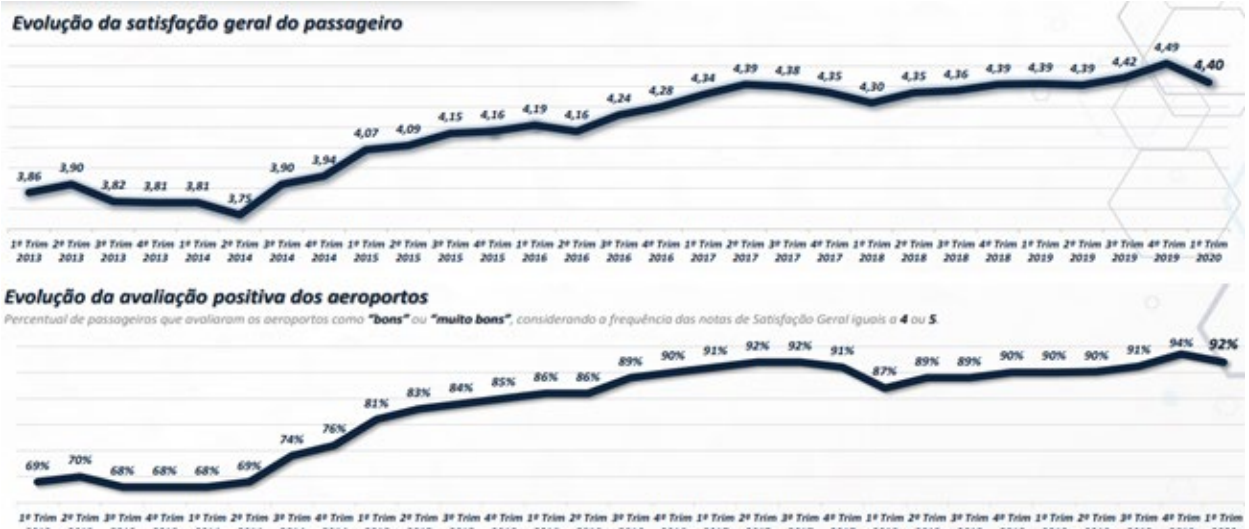


Figure 1 - Evolution of general passenger satisfaction and evolution of positive assessment of airports (Source: SAC / Minfra)

### 3.3 INFRAERO Airport Services

Considering the availability of staff given the concession of its airports and the knowledge learned over its 48 years of existence, Infraero Airport Services offers customized solutions, planned and executed according to the needs of its administration and regulatory systems and a vast portfolio of services and technological products, in technical areas, management and operation, aligned with what is most current in the airport segment (Infraero, 2021).

Currently, the public company is carrying out the administration by contract with States or Municipalities that holds the concession of the exploration, of 5 small airports: Divinópolis (MG), Guarujá (SP), Ipatinga (MG), Parnaíba (PI) and Planalto Central (DF).

One alternative to promote the technical enhancement of airports administration would be including Infraero as one of the partners on the sponsored concession programs or contracted directly to manage the block.

### 3.4 Remote solutions in aviation

The Human creativity, the various technological and scientific advances experienced in recent decades and the humanity's constant search for economic progress have enabled, year after year, the breaking of paradigms and the redefinition of ways of working, a fact that shows itself as an irreversible trend.

In this context and as a preparation for this Paper, it is important to mention some successful examples of the use of remotely controlled air navigation services in places that depend on small regional airports, which have low levels of traffic. These are airports that have low revenues and insufficient or even non-existent state investments, which have historically been subjected to deterioration or even the closure of their activities, which is why there was a need to think of creative technology capable of reducing operating costs without compromising safety.

First, we highlight the Swedish experience, which, through the company SAAB, implemented the remote-control tower solution in several airports, enabling the provision of navigation assistance in a control center placed on hundreds of kilometers away. Sweden is a relatively small country, with approximately 10 million inhabitants that inhabit 450,000 km<sup>2</sup> (less than one third the size of the State of Amazonas). The country has several small airports, with low traffic volume and, therefore, lacking in sustainability, but with great importance for local connectivity. The implementation of a remote air traffic control service made it possible to significantly reduce operating costs, while maintaining the desired level of safety. On the SAAB website, the company points out the following benefits related to its Digital Tower (r-TWR):

- I. Flexible, scalable architecture – the Digital Tower supports multiple use cases, each requiring different camera and visual presentation configurations.
- II. Enhanced visual situational awareness – with features such as graphic overlays, surveillance labels correlation, and on-screen data presentation (e.g. MET data).
- III. Proven, reliable technology – Saab-designed environmental protection provides a clear view in all weather conditions, 24/7, 365 days a year.

Likewise, Japan implemented the remote flight information service (remote AFIS). The country has most of its territory formed by 4 islands that contain about 380,000 km<sup>2</sup>, an area smaller than that of Sweden and equivalent to the sum of the areas of the Brazilian States of São Paulo and Rio de Janeiro. The country has about 60 aerodromes, with only 7 of them with annual movement above 100,000 and 40 of them with annual movement below 20,000. Half of the country's airport network is served by 8 remotely installed centers, called Flight Service Center, located in larger cities, which have been operating effectively for over 20 years in Japan (OLIVEIRA and MONTEIRO, 2015). According to the working paper presented by the Japanese State at the 39th ICAO Assembly, the following benefits were measured:

“(…) with the implementation of remote air-ground communication service in place of aerodrome air-ground communication service from 1994 to the present, a number of FIO have been reduced and nowadays it brings reduction of staffing cost with more than 300 million yen every year.

In addition, maintenance costs for control tower building become no longer necessary and overall maintenance costs for the service are less expensive.”

In Brazil, remote AFIS is not a widely used resource, but there are also successful cases, such as the one at Fernando de Noronha airport that deserves to be mentioned. The airport located in Fernando de Noronha, a Brazilian island with difficult access located in the State of Pernambuco, was selected for the pilot project for the application of R-AFIS, given the difficulty of supporting human resources at the location. After a period of testing without problematic interurrences, the operation was inaugurated in December 2016, after which there was a significant improvement in the coordination between AFIS and the Recife Area Center, as the institutions started to operate in the same operational environment, in addition to optimizing human resources and improving working conditions (OLIVEIRA, 2017).

In view of the above, airport management is undergoing a significant transformation in terms of its management model, so that old systems and equipment are giving way to more efficient and integrated technological solutions. Technologies continue to be constantly developed and improved, so that numerous innovations must be presented in the coming years, and it is precisely in this environment that the proposal of this work is inserted.

### 3.5 Remote Command-and-Control Centers

During the great events period in Brazil, (World Cup 2014 and Olympics 2016), the experience of remote management was developed, with the use of Command-and-Control Centers, that allowed the continuous monitoring of current operations and the constant interaction of different authorities with fast and reliable access to important information and decision making.

The use of video walls and advanced telecommunication structure proved to be the best option for constant overlooking, with a highly effectiveness rate at a lower cost.

This successful experience proved to be an effective option for the government services necessary for the airport operation, since with a Command-and-Control Center all the necessary authorities could perform their duties remotely.

The operation of several airports can be concentrated in one single Center, allowing huge savings for the government, since it would not be necessary to build all the necessary structure in each airport, besides making it easier to retain qualified labor force, since the professionals would not have to move to the small location of the airports, since the centers can be located at the capital city.

### 3.6 Solutions for management enhancements

It is indisputable that for a good overall management it's necessary a good human resources management, what includes adequate personnel selection, investments on training and personal development and a talent retention program, that will guarantee that the employees will keep on working after the capacitation.

The small airports in Brazil are usually owned by the State or Municipality, and in most cases the administration of these airports is carried out by the local politicians, and in these cases the hiring of the employees does not take into consideration the technical capabilities, instead, it is only a matter of political affinities.

It has been observed during ANAC'S oversights that the higher administrators of the airports usually start the job without any knowledge related to the area, taking many years to build the necessary knowledge base, only to be substituted by another person, without any knowledge, who is related to the new mayor or governor.

The development of the necessary knowledge base and professional experience takes many years, besides being expansive, what is impracticable for many municipalities, resulting in a bad administration of the airports and consequently on several operational restrictions that could easily be fixed with a minimum professional engagement.

We believe that a professional administration, with a solid knowledge base and adequate human resources management will contribute for the development of the State of Amazonia airports development.

The concession of airports in clusters will allow the unification of administrative procedures, besides making it possible for the central administration to invest more resources on training and education of the professionals, hiring highly specialized administrators and retaining the qualified labor force.

## 4.DISCUSSION

The prototype suggested in this paper basically consists of a management model in blocks to enable the sustainability and promote operational safety, security, and accessibility of airports, improving efficiency through the adoption of remote operating technology and advanced administration methods. With the implementation of a central nucleus dedicated to the management of a block of airports, we would have the centralization of airport activities related to planning, to administrative issues, such as the management of human resources, materials and contracts, as well as strategic decision-making at a high level, while at the same time reducing costs.

The central unit under discussion could be in some convenient location which meets the business model of each group of airports, thus avoiding the need for high-level professionals to reside in remote locations, which is also a hindering factor in the traditional model, notably in the Legal Amazon region. And this aspect is essential in the proposed model, considering that these professionals would need to hold a high-level technical qualification, capable of, among other activities, remotely assessing the necessary investments for each aerodrome, monitoring the safety and efficiency of the operations, the deterioration of infrastructure and the performance of the specialized teams that provide on-site services, which, logically, would continue to exist to provide maintenance activities and essential assistance to the airport's routine.

As stated above, we currently live in a context of technological advances and society's adaptation to tools that enable close contact between people, even if they are miles away. Technological resources such as high-speed internet and smartphones equipped with the most varied applications and with high-resolution cameras, as well as tools well disseminated in the professional daily life, such as applications

for the exchange of instant messages and professional social networks, could significantly contribute to the feasibility of this proposal.

And why would this proposed model prove interesting in Brazil, especially regarding regional civil aviation in the Legal Amazon? Brazil has a significant percentage of aerodromes with low traffic volume, a factor that makes infrastructure investments unfeasible (OLIVEIRA, 2017). In this context of low economic power of regional aerodromes, any cost reduction proves to be of great relevance to make their existence viable. The proposed model brings the benefit of reducing the operational cost of these airports, bringing them closer to sustainable development, at the same time enhancing safety and the quality of the services to the society.

Assuming that airport management cannot be automated, as the human element is currently indispensable to this function, the centralization of airports' high administration makes it possible to invest in better professional qualification, what translates into better coordination, offering greater efficiency in the application of this resource.

In addition to cost reduction, it would be possible to obtain other benefits such as an improvement in the service level because of the flexibility of the technical staff to dedicate themselves according to demand, thus reducing waste in the labor applied to this activity. In addition, in a *sui generis* region such as the Legal Amazon, full of particularities, the proposed model could allow an aerodrome of the group to take advantage of the positive experience of another aerodrome, also generating, on the contrary sense, constant learning resulting from negative experiences.

As a positive externality, by enabling the airports in question to become sustainable, the management model proposed in this Paper could guarantee the integration of the Legal Amazon to the rest of the country, as it allows populations located in places which are isolated from the main urban centers to connect quickly and safely.

However, it is also relevant to discuss the concerns related to the implementation of the model suggested herein – concerns that can be easily imagined using as a reference the case of remotely controlled towers, previously exemplified in this work. According to Oliveira and Monteiro (2015), some risks must be considered for a safe operation of r-AFIS, such as technological risks associated with operating equipment and networks and telecommunications that interconnect the remote station to its base of operations. Also, according to the mentioned authors, if these problems occur in a remote location, the time spent by a technician for effective maintenance can compromise operations, which is why they recommend equipment redundancy.

Bringing these concerns to the proposed model, we must consider that communication difficulties with remotely located teams may occur due to connection problems, especially because the operations will take place in the interior of the country, in places with precarious infrastructure. However, this is a problem that is considered mitigated, seeing that there are technological conditions capable of providing redundancy in the supply of energy and communication resources, without forgetting the fact that there will be local teams providing support for operations, which can receive adequate training to act in the event of a crisis.

It is also important to consider the importance of investments in cybersecurity since all communication infrastructures can be subject to cyberattacks.

In terms of options for the management and operation of the aerodrome block we can raise the following possibilities:

- Option 1: Concession of airports;
- Option 2: Infraero Airport Services;
- Option 3: Sponsored Concession (PPP).

According to CNT (2021) in general terms, concessions are going well. The planned investments are being made to the satisfaction and the modeling of block concessions is more appropriate than the one that was being made initially, asset by asset. In addition to the gain in national infrastructure, since investors must think about the development of all the airports in the blocks, thus impacting the whole regions, it also has the potential to boost investments. The reason for this is the balance of the airports in the blocks, since each of them has a large airport as an anchor and others with good potential for demand growth, which is very interesting for the investor.

However, in the case of the airports block object of this study, there is no airport that could be considered as anchor of the block, that is, there is no asset in conditions to earn revenues that can cross-subsidize the other airports. In fact, all are small airports with little or no vocation for increased traffic, which makes it impossible to model that results in a positive Liquid Present Value (VPL). Therefore, this option does not seem to be suitable for the proposed airport block.

It should be considered the inclusion of Infraero as one of the partners, considering its extensive experience on airport administration and specialized infrastructure, that will bring the necessary expertise for the block administration. However, considering that on the end of 7<sup>th</sup> round, Infraero will have practically no revenue and the Ministry of Infrastructure is interested in extinguishing the company (INFRA, 2021), this option could be not feasible, because the future of the company requires a political decision.

Considering the low operation volume of these airports, what means that they operate with a low-income flux, it is important to take into consideration the necessity of economical supplementation for their sustainability.

Such subsidy can come from cross-supplementation, where highly profitable airports are offered in an indivisible group with in-deficit ones, what is not possible in this case, since all airports in the group have the same characteristics, or from a more direct government supplementation, in the model of a Sponsored Concession, where the government will pay for the private concessionaires of the airports a previously agreed tariff supplementation or another way that allow the equilibrium of the system.

It is important to highlight that public-private partnerships (PPPs) are also concession contracts but have as their object a public service that is not remunerated only by the fees of users, or a public enterprise of which the Government itself is the user. Unlike common concessions, in PPPs the concessionaire's remuneration comes in part, or all of it, from the payments from the Government. There are two modalities of PPPs: sponsored concession and administrative concession (PPI, 2021).

According to Law Nº. 11.079, the sponsored concession is the concession of public services or public works that Law Nº 8.987 deals with when it involves, in addition to the tariff charged to users, the public partner's cash compensation to the private partner. Administrative concession is the contract for the

provision of services that the Public Administration is the direct or indirect user, even if it involves the execution of work or supply and installation of goods.

In other words, the sponsored concession is the concession of public services or public works in which there is a fee charged to users, but which is insufficient to remunerate the concessionaire. The contract then provides for the payment of a cash payment by the public partner to the concessionaire (sponsorship). There are several cases of subway transport and basic sanitation that fall into this category. The administrative concession is the one in which the Public Administration is the direct or indirect user of the service, and the concessionaire's remuneration is derived from payments paid by the Government, without charging the user's fees. Examples of this type of PPP include administrative centers and prisons (PPI, 2021).

According to Law 11.079, that establishes the general rules for bidding and contracting a public-private partnership, the public-private partnerships is forbidden in the following cases: the value is less than R\$ 10,000,000 (ten million reais); II - the period of the service is less than five (5) years; or III – which has as its sole object the supply of labor, the supply and installation of equipment or the execution of public construction, so, the concession of the State of Amazonia Airports under this concession modality will have to meet these requirements: the contract must be effective for more than five years and must not be restricted to only one object, instead, englobing the improvement works, administration and operation of the airports.

## 5.CONCLUSION

As explained, Brazil is a huge country with great cultural, social, and economic diversity, and it is therefore important that the Brazilian State seeks the development of all its regions, providing opportunities for sustainable growth in a harmonized manner throughout the Brazilian territory. The integration of small towns in Legal Amazon is very important for their social-economic development, and such integration requires an adequate transportation infrastructure.

The interior of the Amazon Region presents itself as one of the most isolated regions in the world in view of its great difficulty in accessing and, consequently, its lack of development. Due to its characteristics, the Amazon Region, with all its forest, rivers, soil typology and the absence of roads – and in some cases the technical impossibility to build them – cannot depend on its transport infrastructure on terrestrial connection, remaining fluvial navigation and air transportation.

Considering the huge distances involved, air transportation is the best option for the region in most cases but depends on the existence of airport infrastructure for the operation. Due to the low operation volume and administrative problems, the existing airports do not offer the necessary conditions for the commercial aviation development.

Considering this context, this Paper had as its main objective to explore possible solutions to promote the sustainable development of a group of small airports located in the State of Amazonas using integrated management, maintenance and operation processes, as well as the use of remote technologies that allow the monitoring and decision-making of these processes centrally, resulting in an efficient and sustainable management model.

In this sense, this study sought to identify integrated management models applicable to the reality of these airports, as well as technological solutions that allow the reduction of operational costs and at the same time allowing operations to take place in compliance with regulatory requirements. Thus, this paper has proposed specific actions to enhance the efficiency and reducing costs while at the same time promoting safety enhancements, to make these airports sustainable at the long term.

Focusing on the State of Amazonas, we have identified a group of airports, located at small cities, that shows reasonable development capacity, with a good geographic positioning to promote the regional integration of the state, which are the airports of Parintins, Carauari, Coari, Eirunepé, São Gabriel da Cachoeira, Barcelos, Lábrea and Maués. This group of airports is already under study phase aiming its concession for private administration.

In order to make this concession economically feasible, we have proposed that the administration of these airports should be centralized in one single administration group, that would promote the necessary resources administration enhancements, improving efficiency through the adoption of remote operating technology and advanced administration methods, to enable the sustainability and promote operational safety, security, and accessibility of airports. As explained above, the proposed model would offer several advantages, such as:

- (i) cost savings;
- (ii) the allocation of this specialized technical center in a convenient place which meets the business model of each group of airports, thus avoiding the need for high-level professionals to reside in remote locations;
- (iii) the optimization of human resources since the centralization of airports' high administration makes it possible to invest in better professional qualification and to make the optimal use of human resources, considering that the employees can dedicate themselves according to demand, thus reducing waste in the labor applied to this activity;
- (iv) the optimization of material resources, considering the needlessness to maintain different infrastructures in different locations performing the same function;
- (v) the centralization, in a specialized technical nucleus, of the airport activities related to planning, to administrative issues, such as the management of human resources, materials and contracts, as well as strategic decision-making at a high level, what translates into better coordination; and
- (vi) the integration of the Legal Amazon to the rest of the country.

We have also proposed the adoption of technological enhancements that will make it possible for most of the operation coordination to be made from remote positions, such as remote-control towers (R-TWR) and remote air flight services (R-AFIS), on a centered command-and-control center for the whole group, enhancing the efficiency and safety of the operation while at the same time saving economic resources. It is a solution with international support, emphasizing the Sweden's experience in operating remote-control towers (R-TWR) and the Japanese experience in operating remote air flight services (R-AFIS).

In Brazil, we also mentioned successful experiences, such as the pilot project for the implementation of remote TWR in the Santa Cruz Air Base/RJ, the R-AFIS of Fernando de Noronha Airport operated remotely from CINDACTA III in Recife/PE and the implementation of automatic surface meteorologic stations (EMS-

A) that provide meteorological data through VHF broadcasting directly to pilots and transmitted to the International Bank of OPMET messages of type METAR AUTO and SPECI AUTO, without human intervention.

Still considering the low operational levels, and consequently low revenues, we have proposed that the Public-Private Sponsored Concession model should be used, where the government will pay for the private concessionaires of the airports a previously agreed tariff supplementation as way to allow the equilibrium/sustainability of the system.

The adoption of the remote operation coordination and administration will require an initial investment, both on telecommunication infrastructure on the remote locations and building of the command-and-control center, but the efficiency gain will compensate for it at the long term.

It must also be taken into consideration that, to avoid technological risks associated with operating equipment and networks and with the telecommunications that interconnect the remote station to its base of operations, this solution will require constant investment on software licensing, telecommunication infrastructure maintenance, cybersecurity resources and personal trainings, always considering the necessary redundancy for emergency situations.

We believe that these suggestions will help to integrate the management and operation activities for a group of small regional airports located in the State of Amazonas building a network that, in the long run, is more likely to become economically sustainable.

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