POTENCIAL IMPACT OF RUNWAYS EXPANSIONS

Raul Sandoval Cerqueira
M.Sc. Civil Engineer (UNICAMP)
M. Sc. Air Navigation Management (ongoing ENAC)
Civil Aviation Regulation Specialist - ANAC
SMPW Qd.22, CJ.02, Lt.03 Casa D – Parkway, Brasília / DF. CEP.: 71.745-202
Telephone: +55 61 3314 4238 E-mail raul.cerqueira@anac.gov.br

ABSTRACT

The National Aviation Plan 2018-2038 (PAN) comprised a broad analysis of the national aeronautical scenario guiding the investments in infrastructure. Complementary studies are important to deepen in specific aspects of the development of airport infrastructures.

In this context, covering only a small aspect of this vast subject, this study was elaborated with the objective of analyzing the potential impact of the expansion of the runway regarding its capability.

As result, a list of airports has been identified for which the expansion of the runway should be assessed in the case of scheduled commercial flights operation.

Keywords: Runway length, Runway Capability, Infrastructure, Airport, Scheduled Flights.

1. INTRODUCTION

The improvement of the national aerial network to enable flights in optimal operating conditions is a goal to be sought by all entities involved in air transport.

Airports, while points of the aerial network, have physical characteristics that significantly influence the quality and capacity of the system as a whole.

Qualifying such infrastructure consistently has the potential to impact the national economy in the most diverse sectors and regions, which motivates the search for information that illustrates the current scenario and the possibilities of evolution, complementing the efforts continuously undertaken by the institutions that direct the sector.

In this context, covering only a small aspect of this broad subject, this study was elaborated with the objective of analyzing the potential impact of the expansion of the runway in airports regarding its capability.

This objective required the adaptation of the runway design methodology in order to allow the establishment of a numerical indicator, which was analyzed using air movement data, aircraft performance diagrams and national airport information, generating, finally, the analysis of runway capability as intended.

2. REVIEW

2.1. Brazilian airport planning

The National Aviation Plan 2018-2038 (PAN) brought significative advances, as it consolidated planning efforts dispersed in different public instruments that preceded it.

The PAN defined a specific direction for the development of national aviation, outlined in 09 objectives, from which the detailed study of demand and its effects on the national aerial network resulted in a proposal for the expected development and estimation for the investment to be carried out at each of the national airports.

The extensive analysis made it possible to identify that the current infrastructure has installed capacity to support the demand until the year 2025, and given the uneven distribution of the infrastructure, some airports may need investments in shorter term and others in longer term.

> *"It is noted that the installed capacity of Brazil's airport infrastructure in terms of annual passenger processing capacity is sufficient to absorb the demand for regular passenger until 2025. However, both demand and capacity of the airports have a differentiated geographical distribution, since there is a greater concentration of passengers in the big cities that can lead to the need to expand specific infrastructures in a closer horizon, while others in a long term horizon. " (Translated from MTPA, 2018)*

Details on which investments to prioritize have been evaluated for some airports and the analysis of the infrastructures to be improved have been relegated to future studies, include in this scope the analysis of the length of runways.

2.2. Infrastructure and performance of aircraft

An aerial connection is conditioned by several interrelated factors that must be considered by the airport operator when sizing the infrastructure.

Modifications to these variables have a significant impact on the economic result of a given operation. Notably in the topic of this study, if the initial aerodrome has a runway that limits the takeoff weight below the aircraft performance, the flight cannot occur with optimum use of the aircraft.

> *“Airplanes today operate on a wide range of available runway lengths. Various factors, in turn, govern the suitability of those available runway lengths, most notably airport elevation above mean sea level, temperature, wind velocity, airplane operating weights, takeoff and landing flap settings, runway surface condition (dry or wet), effective*

runway gradient, presence of obstructions in the vicinity of the airport, and, if any, locally imposed noise abatement restrictions or other prohibitions." (FAA, 2005)

Some runway characteristics like instruments or taxiway system affect mostly the quantity of movements per hour that it will be able to perform, what is usually called "Capacity".

Otherwise parameters like runway length affects mostly the type of the movement that it will be able to perform, what IATA called "Capability".

"Capability Is the compatibility of the facilities with the size and type of existing and forecast traffic." (IATA, 2019)

The runway length is sized based on the intended operations at the aerodrome, so it is a capability limiting parameter.

"The design objective for the main primary runway is to provide a runway length for all airplanes that will regularly use it without causing operational weight restrictions." (FAA, 2005)

"Runway length is a limiting factor on aeroplane operations and should be assessed in collaboration with the aeroplane operator." (ICAO DOC 9981, 2016)

Regarding the aerodrome, changes in declared distances, weather conditions, approach segments, or even obstacle-free surfaces in their vicinity, among others, may influence the required minimum length of runway.

Concerning the aircraft, different configurations of weight, thrust, speeds, flaps, among others, also change the required minimum runway length.

"The actual runway length to be provided for a primary runway should be adequate to meet the operational requirements of the aeroplanes for which the runway is intended and should be not less than the longest length determined by applying the corrections for local conditions to the operations and performance. ..."

"...Note 3. - Local conditions that may need to be considered include elevation, temperature, runway slope, humidity and the runway surface characteristics."

(ICAO ANNEX 14, 2016)

Infrastructure is planned and built for specific purposes, however, over the years, such infrastructure may be used for new purposes and this will require investments for its adequacy.

"Introducing new types of aeroplanes into existing aerodromes may have an impact on the aerodrome facilities and services, in particular, when the aeroplane characteristics exceed the parameters that were used for planning the aerodrome." (ICAO, DOC 9981, 2016)

2.3. Aircraft operating in the country

It is assumed that an airline sizes its fleet to operate a portion of the aerial network that allows economic return for these operations, which is dependent on the existing demand for each connection and also the conditions in which such air connections can be made.

In this sense, the number of commercial aircraft currently operating scheduled flights in the country would be in line with the existing infrastructure or that will exist in a short or medium term.

National airports and the regions served by them are heterogeneous and this heterogeneity translates into different compositions of the aircraft group that performs the operation, as can be seen in the following section of the PAN:

"It can be observed that the great majority, by the estimate of demand and the characteristic of the route

(short or medium distance), could be operated by aircraft of up to 30 passengers (85%, or about 4000 connections) and others have potential for operation of aircraft of Category 3C or higher (15%, or about 600 connections).” (MTPA, 2018)

In addition, it is possible to say that for a single set of aircraft (Mix), reducing infrastructure constraints would enhance the operation economical suitability in previously unfriendly locations, and aerial routes would be more competitive if the airports connected by them provide economically appropriate conditions for the operation of a wider range of aircraft, in particular if it reaches heavily operated aircraft at major airports in the country.

3. METHODOLOGY

3.1. Identification of the Mix of aircraft operating at main airports

The Mix of aircraft that realized scheduled flights was identified from the movement registered data, during 03 months in the main airports of the country from the RIMA report (ANAC, 2018).

The major airplanes operating scheduled commercial flights in this set were then selected and this subset was titled "Mix Brazil".

3.2. Performance characteristics of the aircrafts

For each of the aircraft identified as "Mix Brazil" components, the "APM - Airport Planning Manual" provided by the respective manufacturers was obtained (Airbus A330, 2018; Airbus A319, 2019; Airbus A320, 2019; Boeing 767, 2005; Boeing 737, 2013; Boeing 777-200LR/300ER, 2015; Boeing 787, 2018; Embraer 195, 2015).

The performance abacuses extracted from these manuals were tabulated in a spreadsheet in order to facilitate their use in the different calculations to be performed.

3.3. Adaptation of design methodology

In this study, the analysis of the available infrastructure in terms of runway length is carried out by means of an indicator, which was obtained from the adaptation of the runway design methodology described by the FAA - Federal Aviation Administration in the Advisory Circular AC 150 / 5325-4B and the ICAO Doc 9157 – Part 1 (2006).

Originally, the provided methodology was carried out in steps, summarized herein: identification of critical design aircraft and the weight in which the aircraft would perform the take-off and landing operations; using the aircraft performance abacuses, provided by its manufacturers, to obtain the length of runway required for takeoff and landing; applying the correction factors; Finally the required runway length would correspond to the highest value obtained between the two cases (take off or land) and, in the case of the primary runway, this should be such that it would not cause restrictions on the operating weight.

The adaptation was necessary so that, from the length, altitude, temperature and slope of an existing runway and considering a list of aircraft that has the potential to operate at the airport, it would be possible to identify the operational constraints related to the existing runway.

Also, the length required for landing was not included int the analysis scope.

As previously addressed, the intended objective is the evaluation of the existing runway and not the design of a new one, thus the adapted methodology can be summarized in steps, herein:

A. Identification of runway data: length, altitude, slope and reference temperature;

B. Identification of each aircraft to be evaluated;

C. Obtaining the abacus “Runway length required for takeoff” X “Takeoff weight”;

D. Using the abacus of step C, from the existing runway length to obtain the maximum takeoff weight possible for each aircraft of the Mix.

3.4. Indicator relating to existing runway length

The indicator to evaluate the potential constraints imposed by an aerodrome runway extension was defined as the percentual reduction that the calculated maximum weight represents in relation to the Maximum Takeoff Weight (MTOW) of the aircraft.

It is known that most of the operations of an aircraft occur in a weight below its MTOW, depending primarily on the pay load and range it intends to fly and, due to that, it must be highlighted that the indicator does not represent actual runway operational restrictions, it only aims to provide a first step to assess them.

Hence, wind, temperature variation, existing obstacles, noise abatement special take off procedures and declared distances may be significant and were not considered in this analysis.

Aiming to identify possible improvements to the runways that would enhance the Brazilian aerial network operations, the indicator was calculated for all "Mix Brazil" aircrafts and the value of the indicator for the Mix is the average weighted by the incidence of each aircraft in the Mix.

4. ANALYSIS

4.1. Identification of the Mix of aircraft operating at main airports

Based on ANAC's data through the "Airport Movement Information Report - RIMA", defined by ANAC Resolution 464/2018, covering the months of October, November and December of 2018, covering 15 airports (SBBR; SBCF; SBCT; SBEG; SBFL; SBFZ; SBGL; SBGR; SBKP; SBPA; SBRF; SBRJ; SBSG; SBSP; SBSV), it was possible to compose Table 1, which identifies the set of aircraft that operated at these airports during that period. entitled "Mix Brazil".

Table 1 - Aircrafts operating in the major Brazilian airports - "Mix Brazil"

Mix Brazil		
Aircraft	**Registered movements**	**Incidence**
A 319 100 / NEO	52.885	10,76%
A 320 200	151.012	30,72%
A 320 NEO	2.003	0,41%
A 330 200 / A 330 300	7.269	1,48%
B 737 700	44.150	8,98%
B 737 800	143.019	29,10%
B 767 300	3.580	0,73%
B 777 200	3.565	0,73%
B 777 300	3.753	0,76%
B 787 8	851	0,17%
B 787 9	780	0,16%
ERJ 195	78.650	16,00%
Total	**491.517**	

4.2. Indicator evaluation

From the “List of public aerodromes” (ANAC, Register of public civil aerodromes, 2019), the ADC Charts (DECEA, 2019) and data from the ICEA Climatic Data Bank (ICEA, 2019) were gathered airport characteristics data.

Using the adapted methodology, the theoretical weight reached for the Mix was calculated, and then, the indicator "Potential loss by take-off limit (%)" was calculated.

This indicator provides a value between 0% and 100% referring to how much the runway restricts the potential of take-off operations in terms of the MTOW.

The results for the airports from the 1st to the 7th round of concessions are shown herein.

4.2.1. Airports of the 1st to the 4th rounds of concessions

The airports in the 1st up to the 4th concessions rounds are all in the list of airports used to identify the Mix Brazil, so, as expected, the values of the proposed index (Figure 1) demonstrates that their runway lengths do not cause significant restrictions on the operation of the most common aircraft in the country and they are fully suitable for scheduled flights operation.

4.2.2. Airports of the 5th round of concessions

The airports in the 5th round of concessions achieved different levels of the indicator (Figure 2) and it is worth highlighting the ones that reached value above 20%:

- SBJU – Juazeiro do Norte / CE;
- SBSI – Sinop;
- SBKG – Campina Grande; and
- SBME – Macaé.

These airports may present significant restrictions to scheduled flight operations and so it is advisable to assess the runway extension for that purpose.

4.2.3. Airports of the 6th round of concessions

Four airports in the 6th round achieved values above 20% for the indicator (Figure 3), which means that would be advisable to assess its runway extension regarding scheduled flights operations:

- SBJV – Joinville / SC;
- SBBG – Bagé / RS;
- SBBI – (Bacacheri) Curitiba / PR;
- SBUG – Uruguaiana / RS;

4.2.4. Airports of the 7th round of concessions

Part of the airports in the 7th round of Concessions achieved high values for the indicator, five of them achieved values between 20% and 60% (Figure 4):

- SBUF – Paulo Afonso / BA;
- SBUR – Uberaba / MG;
- SBMT – (Campo de Marte) São Paulo / SP;
- SBCR – Corumbá / MS;
- SBRJ – (S. Dumont) Rio de Janeiro / RJ;

Important to notice that Santos Dumont Airport (SBRJ), which is among the busiest in the country, is in this group. However, it is notorious that the operations carried out there are subject to restrictions due to runway conditions, which, in a certain way, confirms the indicator value.

The indicator value for three of these runways were above 60% (Figure 4), which indicates that they should be improved for the scheduled flights operations and would require the runway expansion so that this type of operation can occur in an economically more competitive way:

- SBJC – (Brig. Protásio) Belém / PA;
- SBJR – (Jacarépaguá) Rio de Janeiro / RJ;
- SBPR – (C. Prates) Belo Horizonte / MG.

4.1. Infrastructure development proposition

Based on the indicator results and assuming that is desirable to reduce its values to a level compatible with the major Brazilian airports, as low as 5%, a list of new runway extensions was estimated for those airports whose indicator values were high (Figure 5).

As mentioned before, other parameters must be taken in consideration when designing a new runway or a runway ampliation.

It was not in the scope of this article the analysis of the pavement structural condition, the runway width and several other parameters that are relevant to such a decision.

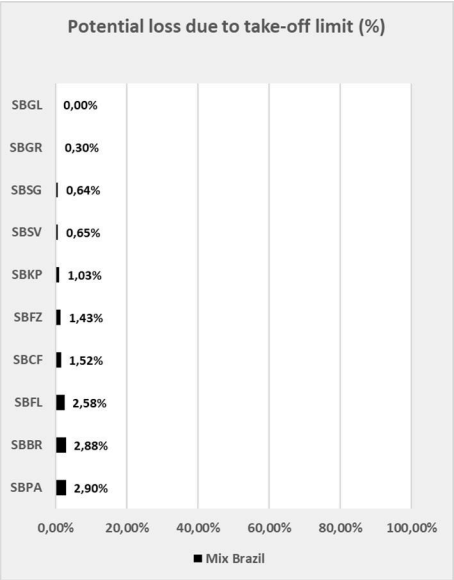


Figure 1 - Airports of the 1st up to the 4th round of concession - Calculated index

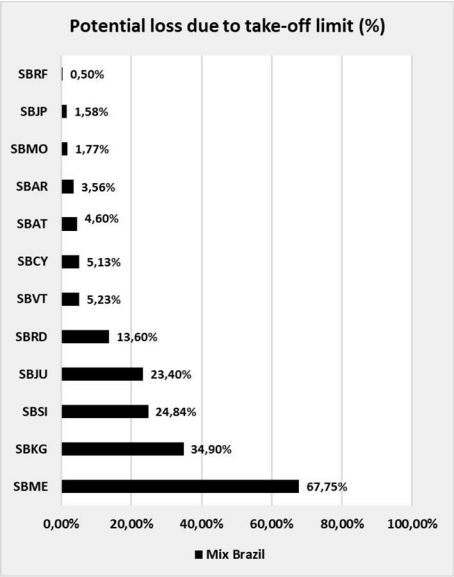


Figure 2 - Airports of the 5th round of concession - Calculated index

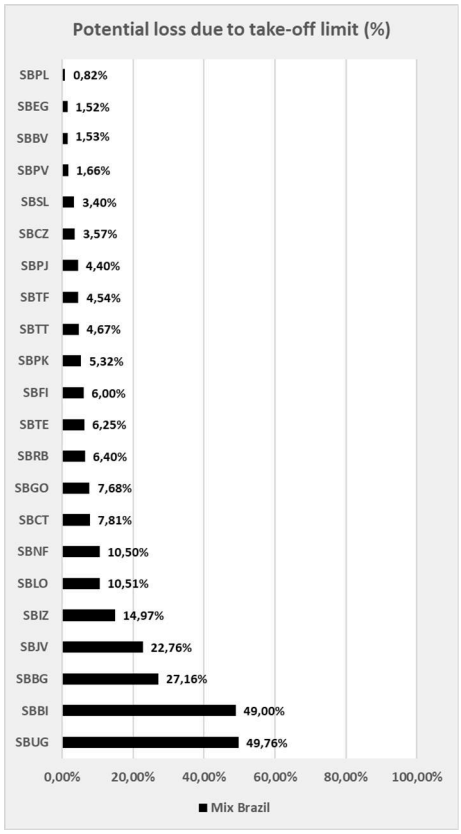


Figure 3 - Airports of the 6th round of concession - Calculated index

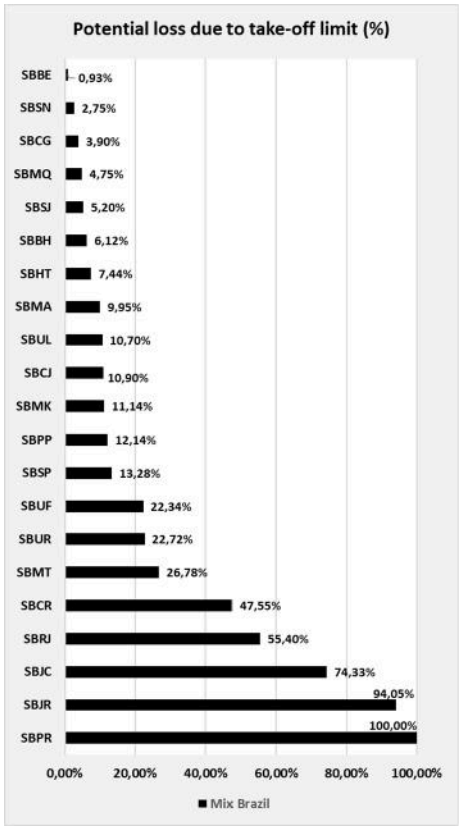


Figure 4 - Airports of the 7th round of concession - Calculated index

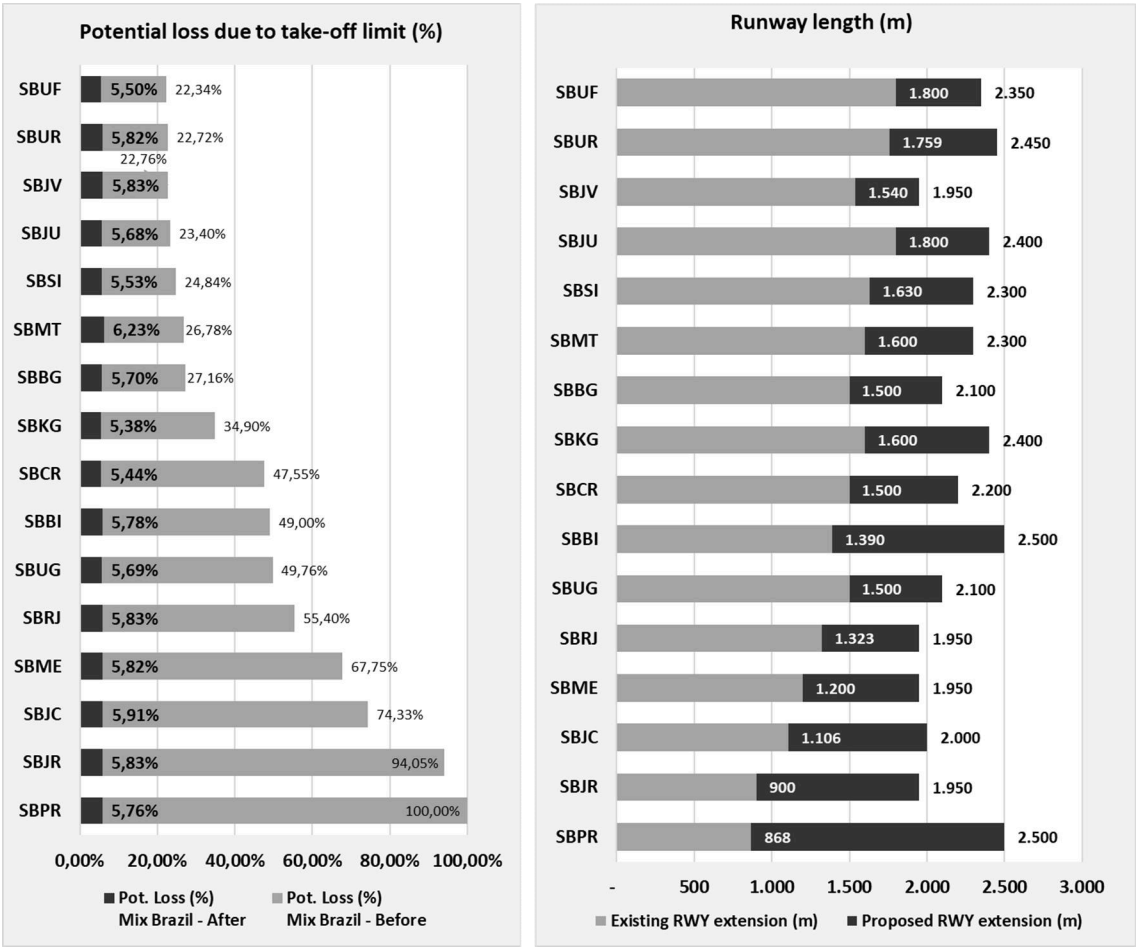


Figure 5 - Proposed new runway extensions and corresponding indicator values

5. CONCLUSIONS

The indicator "Potential loss due to take-off limit (%)" was proposed as a first step in assessing the runway capability once the decision to invest in expansion of the runway involves other factors not covered by the study and the runway design requires more precise methods to be applied.

Calculated indicator values regarding the performance of the most common aircraft operating scheduled flights in the country provided a panel of the airports that were recently privatized and those who are planned to be, indicating those whose runway extension should be assessed and a proposed runway ampliation that will reduce the index levels (Figure 5).

Nevertheless, the potential restriction in these airports were calculated assuming that all aerodromes evaluated have the purpose of carrying out scheduled commercial flights and some of them may have other operational purposes.

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