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Analysis of financial impact resulting from option for aircraft noise reduction against operational optimization at Brasilia International Airport

Análise do impacto financeiro resultante da opção por redução de ruído aeronáutico contra otimização operacional no Aeroporto Internacional de Brasília

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ABSTRACT

This paper proposes to perform an analysis of the financial impact on the air transportation system resulting from the adoption of longer taxi routes for aircraft, both for landings and take-offs at the Brasilia International Airport, due to the impact of aircraft noise in their surroundings, in order to contribute for new operational decisions to be taken by both the airport community, and the civil aviation authority.

KEYWORDS: Financial impact; aircraft noise; operational optimization; operational efficiency; noise curves; taxi routes; noise abatement procedure

RESUMO

Este artigo se propõe a realizar uma análise do impacto financeiro no sistema de transporte aéreo resultante da adoção de rotas mais longas de táxi para aeronaves, para pousos e para decolagens, no Aeroporto Internacional de Brasília, devido ao impacto do ruído aeronáutico em seus arredores, a fim de contribuir para novas decisões operacionais a serem tomadas, tanto pela comunidade aeroportuária quanto pela autoridade de aviação civil.

PALAVRAS-CHAVE: Impacto financeiro; ruído aeronáutico; otimização operacional; eficiência operacional; curvas de ruído; rotas de táxi; procedimento de abatimento de ruído

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1 Introduction

Airports included in the urban structure of a region assume the role of inducing the growth of these places, because they act as a pole converged infrastructure, business ventures and population density. In this context, the second half of the 1950s, with the specific aim of accelerating the development of the newly created Brazilian capital, Brasilia International Airport (SBBR) was opened to traffic.

The airport initial design included a runway of 3,300m length, but the first step has built up a lead of only 2,400m length with 45m wide. This runway, along with the entire grid area of the aerodrome movements, was able to serve between 150,000 and 200,000 annual aircraft movements, depending on the operational mix (considering 12h/day operation). Later his runway was expanded to 3,200m length by 45m wide, further expanding the reach of the airport to more distant parts of the globe. Currently, already with two parallel runways that enable independent IFR operation, has an average of 530 movements/day (195.000/year), with 97.35% domestic operation and 2.65% international operation.

The land use around the airport is predominantly characterized by residential areas, which already in 1984, at the time of the creation of the first version of the Airport Master Plan (AMP) had a considerable population density, as a result of the redirection of vectors of city development.

The fast development of this region brought with relationship problems between the urban side and the airfield. One such problem was represented by the growing noise emitted by aircraft that used to operate there, and factors such as more powerful and more noisy jet engines from larger aircraft and larger number of operations were mainly responsible for the increase in these noise emissions levels (AMP, 1984).

Figure 1 shows the noise curves identified in AMP for the standard operating SBBR in 1984 (85% of the movements performed by the THR 10 and the remaining 15% by the THR 28) and their influences already present on adjacent land. According to the regulations, a Zoning Noise Plan (ZNP) must contain contours of day-night average noise (DNL) of 75 dB (inward curve) and 65 (outward curve) dB.

At the time was developed a detailed study of the needs of airport growth taking into account socioeconomic aspects of the region, access, aeronautical service demands and urban relationships (especially aircraft noise). The planning horizon adopted for the study was 20 years (1984 to 2004), and were identified in this study restrictions on the growth of the first runway (10R/28L), both for the access road to the terminal, and the population density of the residential areas surrounding the airport.

Therefore, in the case of this particular airport, originally two basic determinants of physical planning of the expansion of the landing area were taken into account: the airport capacity and aircraft noise. Furthermore, the configuration of the runways already outlined in the initial project conditioned somehow the possible solutions to reconcile the two variables mentioned. Thus, take to account that a change to a Greenfield was not desirable, the planned expansion of the terminal was comprised in the southern sector of the airport with the construction of the 2nd runway (10L/28R) (Figure 2).

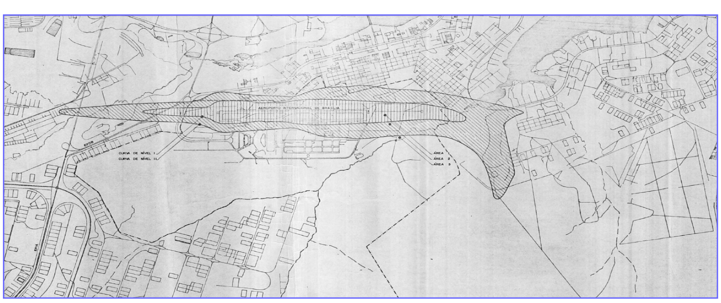

Figure 1.
Noise Curves AMP 1984.

Figure 2.
Selected area for the aerodrome expansion.

In the field's final conception the current runway was maintained with the same geometric characteristics and the second runway, initially planned for 2,400m in length, has presented the possibility of expansion to the current 3,300m. The spacing between centerlines came in 1,800m, enabling simultaneous and independent IFR operations, thereby increasing the operational capacity of the airfield for about 300,000 ATM. Moreover, the strategic positioning of displaced thresholds aimed to reduce the aircraft taxi times (AMP, 1984).

Thus, the configuration named "Bayonet" was envisioned as standard for the new configuration of the airfield, representing, according to calculations by AMP 1984, the situation in which the field would check better operational optimization. Already suggested by the initial design, consisted in having a preferred landing threshold (10R) and in another preferred takeoffs (10L) so as to reduce the taxi times and so spent fuel, resulting in the scheme identified in Figure 3, below.

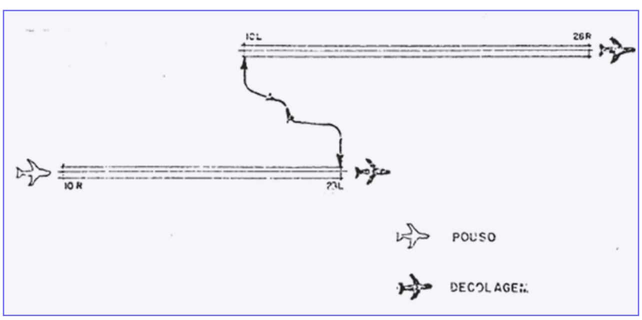

Figure 3. Optimized configuration: bayonet.

However, this configuration was identified as the most impactful for the airport by aircraft noise, because with the increased number of operations, there would be also an increase in the noise curves and so the urban areas under them, since most demand for more powerful engines in takeoffs would contribute more strongly to higher noise levels on the field-adjacent housing sectors (Figure 4).

Figure 4. Noise curves resulting of the bayonet scheme

To manage this type of conflict Kazda & Caves (2008) state that

> to secure an acceptable load of noise around airport sites, four control techniques are commonly used:
> 1. Reduce noise emissions at source by the use of quieter aircraft engines;
> 2. Controlling operational procedures and routing of aircraft, including the optimization of flight procedures and distribution of movements between runways;
> 3. Limiting operations by aircraft type and time; and
> 4. Land use planning aiming compatibility with airport adjacent areas.

Drawing on some of the above principles, was developed in addition to AMP/84 a Specific Aeronautical Noise Plan (Port. 629/GM-5/84) aiming to provide airfield, in the long term, an effective measure to reduce nuisance caused by aircraft noise. It was used for both the control procedures and priority routing of aircraft, reversing the movement of aircraft at the aerodrome, and considering the new system, the configuration of the new noise curves was changed too, as shown in Figure 5.

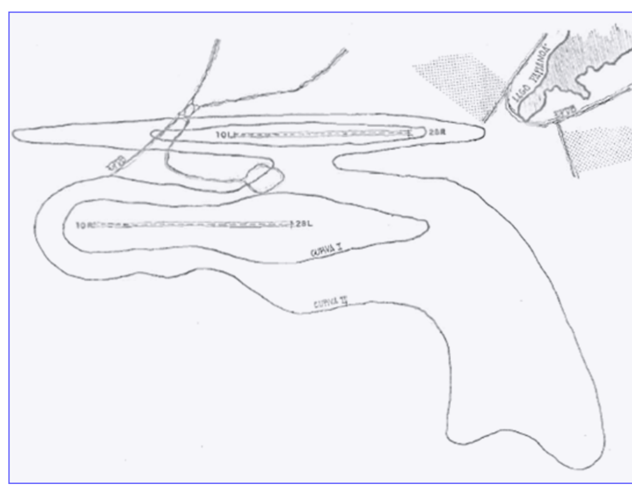

Figure 5. Noise impact with the inverse operation.

This configuration was based on the operation of the airport with a reversion of the bayonet circuit, isolating the urban area of exposure to unacceptable levels of aircraft noise by lateral displacement of approximately 2 km from the noise curves. This new reality would penalize the operational capacity of the airfield, because aircraft would require excessively long taxi circuits.

Thus, the airport operator made a trade-off where the resulting guideline for the airport expansion was the reduction of neighborhood noise impact to the detriment of operational gains. Although the new standard should aim to reduce the noise impact was also required to implement specific take-off procedures in order to reduce noise (Noise Abatement Procedure – NAP). These procedures generally reduce the noise impact on neighboring regions to airport sites, a fact displayed in the noise curves presented, but bring a burden to the operation of the aerodrome and the ability to manage traffic in the airspace affected by the aerodrome.

The Figure 6 below taken from a Standard Instrument Departure chart (ACRE-PAMOP) shows one of these procedures applied to the use for take-off of 11R and 11L threshold, which propelled aircraft turn right after crossing 4,000 feet and jets after crossing 5,000 feet. In addition, all aircraft must maintain a minimum climb gradient of 5.5% until crossing 6,000 feet.

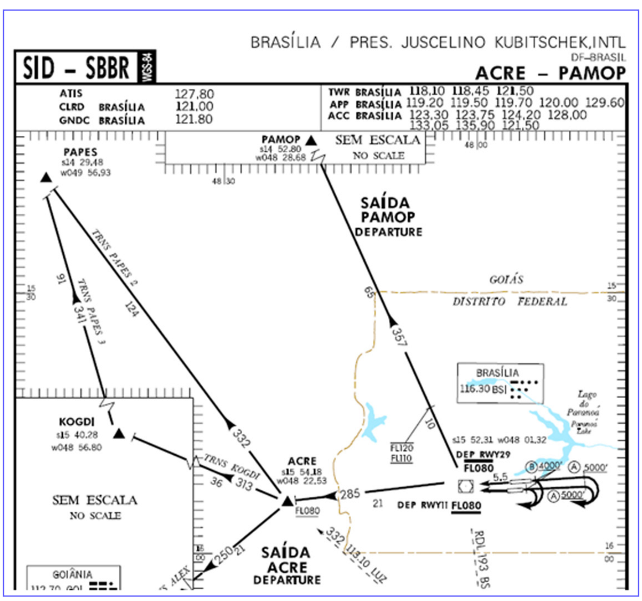

Figure 6. Noise Abatement Procedure at SBBR.

The standard established in the 80's, deployed in December 2005 with the opening of the 2nd runway endures to the present day and in 2010 in order to investigate the evolution of the noise curves of the airfield, were carried out a comprehensive study of aeronautical noise at SBBR, where were found a signature sound that actually reflected the specific operational procedures and the threshold prioritization, similar to that provided for 26 years ago. However it was found that the inhabited area under the curve of external noise (65dB) decreased from size in relation to the amounts previously recorded, mainly due to the fact that now they have the operation of most modern aircraft with quieter engines (Figure 7).

Figure 7. Current noise curves at SBBR.

As the area covered by the inward curve (greater sonic impact – 75 dB) is restricted to the area of the airfield sheet, it was estimated that, considering all the faces surrounding the aerodrome, the inhabited area of the external noise curve now has 582,136m². Taking into account then, the population density of 147.76 inhab./km² (GDF, 2013), this area has an estimated population of about 86 inhabitants.

Therefore, by directly adopting specific operating procedures (NAP) and routing aircraft taxi to prioritize the use of certain thresholds, as well as the growing use of quieter aircraft by airlines, there is currently a considerabe control of the noise levels emitted by aircraft operating in the regions surrounding SBBR.

1.1 Problem and Objective

The standard adopted at the aerodrome circulation, prioritizing noise control at the expense of higher levels of operational efficiency, requires the adoption of measures that supposedly restrict airport capacity, airspace and increase the aircraft operation costs.

So that, not only the airport infrastructure and traffic management find themselves penalized, but also aircraft operators, as these usually end up having to extend their flight paths with higher gradients, which results in significant increase in operating costs, represented mainly by the fuel consumption.

Aware of the problem resulting from a management decision about 30 years ago, the airport operator and aviation authority, in 2012 adopted new patterns of traffic, where between 06:00h and 22:00h takeoffs would be primarily directed at the Threshold 11L, with requirement of maintaining the same high gradients until 6,000 feet. However, between 22:01h and 05:59h aircraft continue to be directed at the runway 11R for takeoff, due to its lateral displacement of 1.800m, which reduces the intensity of noise in residential area around the airport.

Although believed that this new standard will bring some benefit in terms of reduced operating costs, there is still the fact that the airport has operated for about seven years with restrictions imposed by a mid 80's management decision, imposing extra costs to civil aviation market.

Moreover, in public aerodromes, such as Brasilia International Airport, just in case of the occupation of its surroundings without the observance of compatible and incompatible uses specified in Brazilian regulations, there is a possibility of the imposition of operating restrictions by the Civil Aviation Authority, however, these restrictions should be based on an estimate of the financial and economic impact, like a regulatory impact analysis.

Thus, considering that the airport operator demonstrates the tendency to modify its decision to trade-off, this paper proposes to perform this financial impact analysis resulting from the adoption of longer taxi routes for aircraft, both for landings as takeoffs due to the impact of aircraft noise in the vicinity of the aerodrome, in order to contribute for new operational decisions to be taken by both the airport community, and by the civil aviation authority.

2 Methodology

For this study the following methodology was used:

2.1 Desk review of the Airport Master Plan, aircraft noise impact studies performed by the airport operators, the airlines' financial reports available on ANAC website and air traffic regulations (ICA 100-12).

2.2 Collecting operational data from airport operator database, starting in april 2008 and end in december 2012 (57 months), a total of 863,000 frequencies. This period was selected due to the fact that the system used for traffic management by the airport operator has only records from April 2008.

2.3 Were filtered for use movements belonging to the group of commercial operations with scheduled passenger and airfreight. Moreover, were eliminated unreliable data, registry errors and rows with missing data, reducing the sample to approximately 328,000 frequencies.

2.4 Search for data on hour-hour meteorology (METAR) for the same period (41,905 records) and isolated the information concerning the wind direction, wind speed, cloud cover and visibility. The following data were considered for the study for purposes of determining in use threshold:

a) Wind:

1. At speeds less than or equal to 05 knots no threshold prioritization is required (ICA 100-12, Item 10.10.5) and at speeds greater than or equal to 06 knots, the aircraft are necessarily directed to the threshold that provide better utilization of wind (ICA 100-12, item 10.10.5). In any case, considering only wind matters, the preferential threshold was set to:
   - Landings: Thresholds 11R e 29R priority;
   - Take-offs: Thresholds 11L e 29L priority;

b) Ceiling and Visibility:

1. It is considered visual meteorological conditions for operation (VMC) ceiling of 1500 feet and visibility 5000 meters. Any values, both as ceiling or visibility, below these minimums, are classified as instrument meteorological conditions for operation (IMC);
2. For IMC, beyond the constraints of wind, were too considered the minimum required for the type of operation (ILS, RNAV, NDB, VOR/DME and VOR). It was considered for the study, all equipment in full operation.

2.5 The meteorological data were matched with the exact moment of each operation, making possible to identify the wind, ceiling and visibility existing. Excluding the inconsistent values (0.61%), the final sample came to 326,901 (38% of total).

2.6 From the takeoff and landing times data of the four thresholds, parking entrance and exit of the four aprons used in commercial operations (1, 4, 5 and 6) it was possible to calculate the average time taxi practiced at the aerodrome in period. This data had given the function of serving as a comparison between the operations originally planned in bayonet system and the real practiced at the aerodrome.

2.7 Consultation of operational dispatches to the main commercial airfield operating carriers, holding 85% of total commercial operations in order to determine whether the wind of 05kt would have some influence on the choice of the thresholds of these aircraft for takeoff or landing, adopting:

a) Average MTOW practiced during takeoffs;

b) Prevailing dry weather;

c) Average temperature for the period;
d) Set to standard flaps normally adopted for Meteorology presented; and
e) Takeoff Runway Available (TORA).

It was found that these values do not restrict further the sample, keeping then the regulatory limiting of 05kt for threshold adoption.

2.8 Data collection of average cost for one minute of the airlines that operates/operated in Brazil between 2008 and 2011 brought the values of 2013 (U$D 123.98).

2.9 Final calculations of the study, taking into account commercial operations that occurred in thresholds different from the recommended by the bayonet scheme and the difference between the taxi times represented by those operations.

2.10 Estimation of data from january 2006 to february 2008, taking into account that the aerodrome operates with this systematic since late December 2005.

3 Results

From the data used for the study were extracted some operational characteristics of the aerodrome. By using it, it is possible to establish a doctrine of operational management focused on improving the efficiency of the airport as a whole. According to Table 1, the takeoffs showed the type of operation that demands more time taxi and takeoff operation by the 11R THR, although it is less efficient, it is the second most commonly performed in the airfield.

Table 1 – Operations by type and THR

THR	Time (min)	Type of operation	Operations
11R	16,19	Takeoff	177.848
29L*	13,43	Takeoff	55.399
11L*	12,8	Takeoff	65.194
29R	12,1	Takeoff	28.460
29L	9,78	Landing	7.701
11R*	7,59	Landing	24.789
11L	6,9	Landing	215.026
29R*	5,58	Landing	79.385

* Preferential thresholds calculated by meteorological parameters, aid instrument for landings and bayonet pattern from AMC/SBBR.

Regarding the average taxi times of aircraft on commercial flights, it is possible to identify that the logic provided in the original airfield circulation is impaired due to the fact that there is only one access to/from runway 11R/29L (taxiway "K") while the access to the runway 11L/29R, beyond the extension of taxiway "K", there is also the taxiway "J".

Moreover, comparing the two runway systems, it appears that both have identical rapid exit taxiways giving immediate access to taxiways "K" and "J". Because of this fact, the times recorded for both taxi landings on THR 11R, as the THR 29L for takeoffs, theoretically the most advantageous, were higher than those recorded in taxi times on their corresponding parallels, solely on account of lack of access (taxiway "J") to the south runway.

3.1 Financial impact

a) Landings

As mentioned, the financial results calculated for the landing operations proved to be negative (as if they were effective), because 66% of the landings occurred on 11L THR theoretically less efficient, but checked with taxi times smaller, bringing a distortion with respect the gain in efficiency. Negative values gives the false notion that the bayonet system would be less efficient for landings, but times taxi to 11R THR would be smaller than those seen if there was the second access to the south runway.

Table 2 – Financial result: landings

Preferencial		11R	%	Time (min)	Result ($)
Real	11L	164.245	82	(113.329)	-U$D 14,051,102,27
	11R	20.340	10	–	–
	29L	1.280	1	2.803	U$D 347,554.75
	29R	14.397	7	(28.938)	-U$D 3,587,874,21
Total		**200.262**	**100**	**(139.464)**	**-R$ 17,291,421.73**
Preferencial		**11R**	**%**	**Time (min)**	**Result ($)**
Real	11L	50.781	40	67.031	U$D 8,310,828.62
	11R	4.449	4	8.942	U$D 1,108,734.63
	29L	6.421	5	26.968	U$D 3,343,652.28
	29R	64.988	51	–	–
Total		**126.639**	**100**	**102.942**	**U$D 12,763,215.52**
Result landings					**- U$D 4,528,206.21**

b) Takeoffs

In the case of takeoff, the estimated financial result was positive because although 9% of takeoffs occurred by less efficient THR (29R) with negative U$D 3,794,350.15 the result for takeoff operations at the 11R THR proved to be the most expensive the entire circulation of the airfield.

Table 3 – Financial result: takeoffs

Preferencial		11L	%	Time (min)	Result ($)
Real	11L	47.368	24	–	–
	11R	136.108	68	461.660	U$D 57,238,960.98
	29L	10.512	5	6.651	U$D 824,613.08
	29R	5.716	3	(4.093)	-U$D 507,458.21
Total		**199.704**	**100**	**464.218**	**U$D 57,556,115.85**
Preferencial		**29L**	**%**	**Time (min)**	**Result ($)**
Real	11L	17.826	14	(11.349)	-U$D 1,407,803.45
	11R	41.740	33	115.351	U$D 14,301,848.29
	29L	44.887	35	–	–
	29R	22.744	18	(30.603)	-U$D 3,794,350.15
Total		**127.197**	**100**	**73.399**	U$D 9,100,414.69
Result takeoffs					**U$D 66,656,530.54**

Still considering the distortion caused by the lack of taxi infrastructure in the south runway the final efficiency calculation was positive, showing that from March 2008 to December 2012, just in commercial operations, it was realized an additional cost operating of more than 62 million dollars, or more than 1 million dollars per month.

Table 4 – Takeoffs and landings
(no 2nd access to south runway)

Result landings	-U$D 4,528,206.21
Result takeoffs	U$D 66,656,530.54
Final Result (57 months)	**U$D 62,128,324.33**
Final Result (per month)	**U$D 1,089,970.60**

By adopting then taxi times as if the second access exist, it was found that the additional cost caused solely by the absence of the second taxiway access to the south runway was more than 17,5 million dollars and for the whole airport operation it was about 80 million dollars (Table 5).

Table 5 – Takeoffs and landings
(considering 2nd access to south runway)

Result landings	U$D 9,522,896.06
Result takeoffs	U$D 70,450,880.69
Final Result (57 months)	**U$D 79,973,776.74**
Final Result (per month)	**U$D 1,403,048.72**

Finally, it should again be noted that the data presented are for the period of 57 months between april 2008 and december 2012, but the operational standard in force during this period was effectively implemented in January 2006 and therefore there is further 27 months of operation to be taken into account, where it is estimated an increase of approximately 14 million dollars for the real situation without the second access to south runway (total: U$D 76,297,075.74) and approximately 18 million dollars to the estimation considering the existence of the second access (total: U$D 98,216,477.89).

4 Conclusions

The subject brings to the discussion managerial decisions taken when planning the expansion of the International Airport of Brasilia that resonate even today in its operational efficiency. At the time it was already discussed how match airport growth and urban density around it.

It was found later that the noise caused on inhabited areas surrounding the airport proved to be the main guideline for the expansion of the airfield at the expense of operational optimization, mostly because the aircraft that were operating at the time were much noisier of the operating today.

This pattern imposes extra taxi times for aircraft, because the airport geometry is planned to carry out aircraft landings preferably by 11R and 29R runways and takeoffs by 11L and 29L runways, disregarding noise.

The departures were shown as the type of operation that demands more times and taxi operations for takeoff by 11R THR, although being less efficient, is the second most commonly performed in the airfield.

These extra taxi times, applied to the movement of aircraft since the effective opening to traffic of the second runway (January 2006 to December 2012) resulted in the addition of operating costs to civil aviation market at around 76,2 million dollars (without the second access to south runway) and 98,2 million dollars (estimating with the existence of the second access) in values of 2013.

It was also estimated that the absence of the second access to south runway during the 84 months of the study brought to the civil aviation system extra costs of approximately 22 million dollars. The decision when the expansion of the airfield by not building the second runway 11R/29L access proved to be responsible for this operational/financial impact, which concludes that there is a need for immediate construction of this access in order to avoid future additional costs.

By the end, the search for balance between maximum operational efficiency of the airport and its relationship with the urban environment must always be present. However, given the reduction of noise impact caused by increasingly quieter aircraft operations, the low number of inhabitants affected by external noise curve (approx. 86 people) and operating extra costs presented by the option for reverse traffic, it is up to the Brasilia airport community, in conjunction with air traffic authority and population served reassess the need for maintenance, even partially, of the circulation patterns adopted by 1984.

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