EASING THE CONCEPT "BALANCED APPROACH" TO AIRPORTS WITH DENSELY BUSY SURROUNDINGS THE CASE OF CONGONHAS AIRPORT

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ABSTRACT

This paper presents the difficulties found in trying to apply the "Balanced Approach" concept of ICAO (UN-International Civil Aviation Organization) on the noise pollution mitigation at urban Brazilian airports using, as a case study, the Congonhas Airport. It has been discussed by means of alternative operating scenarios, how to make the concept more flexible, aiming to bring the benefit of any additional acoustic comfort, without diminishing the installed capacity and already limited for environmental reasons. The results show that there are conditions for improvement, since there are both awareness of all players involved and permanent and real-time noise monitoring, even if those mitigating measures are not reflected on the noise annoyance models currently adopted for the land use planning.

Keywords: Noise annoyance, noise pollution, balanced approach, noise monitoring

1. INTRODUCTION

"Balanced Approach" is a concept developed by ICAO (International Civil Aviation Organization) in discussions of its Committee of Environmental Aviation Protection (CAEP), during the 1990´s decade, to mitigate noise emission from commercial aircraft. The core idea is that the best solution for mitigating airport noise should be a composition of actions that are divided in four natures, denominated levels, and should be planned and implemented by a priority order:

Level 1 - To reduce noise at the source, with the use of quieter equipment;
Level 2 - To plan and control the land use in the surrounding areas of the airport;
Level 3 - To adopt alternative operating procedures; and
Level 4 - To restrict the period of operation.

Despite this guidance, published in 2007 (*05), regards the planning and the implementation of mitigation measures, its applicability has proven to be limited in urban and heavy-traffic airports. In these cases the noise mitigation requires the adoption of a specific policy action tool (*17) (*13)

This paper aims to discuss the specific case of Congonhas Airport, the largest airport for domestic transportation in Brazil. The characteristics of this airport, some of them common to those located in other large urban centers, such as daily operation period already limited, difficulties of establishing the environmental liabilities with reasonable accuracy, constant pressure from civil society for more restrictions, and the increase of property values in the airport's surrounding areas, are obstacles for the adoption of significant mitigation measures suggested by ICAO.

It also suggests adjustments to the current scheme of airport operation, to produce any additional improvement to the acoustic comfort of the surrounding residents, with no changes of passengers served or operations authorized there. Even such measures not produce detectable effect when using the current noise annoyance metrics, they have potential to become relevant in reducing the aircraft noise perception, due to other factors not related to aircraft noise, known as background noise, and that can only be observed from the implementation of a permanent noise monitoring system. It was used data from a field research conducted during 2009 and 2010, from which the respective results are still valid, because there were no significant changes in both airport operational profile and surrounding area characteristics.

The next section presents a summary of noise annoyance historic to Congonhas Airport. Then, it is exposed the inefficiency of Balanced Approach concept´s application on that airport. The Section 4 describes the methodology adopted and the operational alternative scenarios considered to the airport, as well as the flexible measures assumed. The Section 5 presents the simulation´s results, using LDN metric, and the analysis of the operational scenarios, in terms on noise annoyance predictions, and the Section 6, finally, presents what can be concluded from the study.

2. PROBLEM BACKGROUND

Congonhas Airport, see Figure 1, has gained importance as an air transportation hub and noise pollution source in São Paulo city since 1970, when the Brazilian civil aviation began to operate, more often, jet aircraft with capacity between 90 and 120 passengers in its domestic segment.



Figure 1: Congonhas Airport land limits and its surrounding area
SOURCE Google Earth

The increase in air traffic at the airport brought the inconvenient noise generated by the engines, strongly perceived by the inhabitants of the surrounding areas, already densely occupied. The residents' complaints ended determining the first total closure of airport operations from 01:00h to 5:00h on daily basis, in the early 1980s. Since 1995, Congonhas has been operating from 06:00h to 23:00h, as result of new negotiations with the former civil aviation authority, taken a few years before. The noisier aircrafts, which are currently prohibited to operate across the country, had additional restriction of 2 hours, resulting in a daily prohibition that began at 22:00h and ended at 07:00h of the next morning. Today, the average daily number of operations is 400 (landing + take-off) with the threshold capacity of 40 operations per hour.

Tables must also be arabically-numbered, centralized in the column and followed by the corresponding captions. In light of Table 1, which lists all volumes and issues of JBATS published until 2010, it is important to emphasize that, just like figures, all tables must be in-text referenced using cross-references and should only contain the label ‘Table’ and its number in the document.

3. DIFFICULTIES TO APPLY “BALANCED APPROACH” IN CONGONHAS AIRPORT

The implementation of the Balanced Approach concept, as established by ICAO (*01), has been proved difficult in Congonhas Airport. When considering Level 1 measures, it is observed that almost the entire fleet operating at Congonhas Airport already meets the requirements of Chapter 4 of Annex 16 ICAO and, therefore, they reach the most updated technology in noise emission. This

also makes much difficult establish noise taxes to raise funds for mitigating noise by the increase airport area (*03).

The proposed measures in Level 2 are extremely complex at the moment because the airport surroundings are completely dense and real estate values in the region are higher than the average market value, contrary to what is normally observed (*12). This apparent paradox can be explained, probably, because the night restriction has been applied to the airport for a long time and, consequently, with little risk of being revoked. Urban airports, most of times, are also difficult to be submitted to cost-benefit analysis (*07) (*09). Even that was possible to estimate the noise annoyance cost for this airport, internalize it not always shows positive results (*15). Sound insulation programs to residential buildings are also ineffective in Brazilian airports because the weather – most of time its tropical characteristics make the inhabitants maintain their windows open, canceling any gain obtained with better building materials applied.

The measures proposed in Level 3 appear to be insignificant, because both the strong urban density and the profile of the surroundings occupation do not offer areas less sensitive to noise pollution to be overflown, restricting consequently alternative approach and the take-off tracks. Even there was no urbanized areas to be overflown, flight track changes are difficult because the airport compete for airspace with another two major airports located near it (GRU and VCP), much more busy. Furthermore, the main runway of the airport also had its length reduced formally since 2001, in order to create the new safety areas, demanded by the ICAO´s Annex 14 changes.

Finally, proposals on Level 4 have already been implemented, with the current night closing, considered long for by the airliners (seven hours).

It is observed, therefore, that there is no easy course of action to mitigate the aircraft noise annoyance through the Balanced Approach at Congonhas Airport. In this context, this research sought alternatives within the concept, which could help decision makers to identify other measures to mitigate the annoyance, promoting the improvement of resident´s welfare near the airport. For this purpose, alternative operating scenarios have been developed, taking into consideration, especially, the urban characteristics of the environment, the profile of the airport's users and the routes most used near the closing time operational limits (23:00h and 06:00h). Congonhas Airport, see Figure 1, has gained importance as an air transportation hub and noise

4. METHODOLOGY / DEFINITION OF OPERATING SCENARIOS ANALYSED

4.1- Current noise annoyance: metric adopted

Initially it was necessary to establish the current range of aircraft noise annoyance caused by the Airport using the "noise contours" according to LDN metric (Day-Night Level) (*04), recommended by the FAA (Federal Aviation Administration) and formally adopted by ANAC (National Civil Aviation Agency) (*02). Using the INM (Integrated Noise Model) software, also developed by FAA, two closed curves were calculated and plotted in the airfield vicinity, uniting the values of 62 and 72 LDN. Although current regulations determine that the noise annoyance curves are plotted for 65 and 75 LDN, the adopted values are more compatible to the noise pollution limits to widespread areas with mixed-use and residential predominance (maximum LEq of 55 dB (A) for daytime and 50 dB (a) for the night) (*10), because this occupation feature is the more observed there. A maximum capacity hypothesis was adopted for the number of operations (takeoffs + landings), established by CGNA (Management Center of Air Navigation of Brazil), which is 34 operations/hour, reaching 40 operations during peak hours, being 4 of them reserved for regional aviation, held with smaller aircraft.

Consequently, the 17 hours of airport´s daily operation produce a total of 578 operations allowed, or approximately 210,000 operations per year. This assumed, the operation level is lower than the installed infrastructure capacity, that can reach 50 operations/hour, depending on the

boundary conditions (meteorology mainly). The movement was equally distributed in both parallel runways, with 12% of nocturnal movement (weighted by LDN metric) and 33% of inverted flow on the runway heads (in the south-north direction). Tables 1 and 2 present the summary of the main input data used in modeling. .

Table 1: Congonhas Airport – Air traffic considered for noise curves, assuming maximum capacity and one third inversion runway heads
SOURCE: Author´s compiling from airport ATM data

Aircraft Group (More representative aircraft)	***Share***	***Daily Total (Landing + Take-off)***	***Take-off operations Main + secondary runways***	
			Head 17 (preferential)	***Head 35 (wind invertion)***
Boeing 737-NG	40%	231	**154**	**78**
Day	35%	204	136 (47,6 N e 20,4 S)	68 (23,8 N e 10,2 S)
Night	05%	27	18 (06,3 N e 02,7 S)	10 (03,5 N e 01,5 S)
Airbus A320	37%	214	**144**	**72**
Day	32,5%	188	126 (44,1 N e 18,9 S)	64 (22,4 N e 09,6 S)
Night	4,5%	26	18 (06,3 N e 02,7 S)	08 (03,5 N e 01,5 S)
Fokker F-100	10%	58	**40**	**20**
Day	09%	52	36 (12,6 N e 05,4 S)	18 (06,3 N e 02,7 S)
Night	01%	06	042 (01,4 N e 00,6 S)	02 (00,7 N e 0,03 S)
Learjet 35 / C-500	07%	40	**28**	**14**
Day	06%	34	24 (08,4 N e 03,6 S)	12 (04,2 N e 01,8 S)
Night	01%	06	04 (01,4 N e 0,06 S)	02 (00,7 N e 00,3 S)
DASH 8 / ATR 42	06%	35	**25**	**11**
Day	5,3%	31	22 (7,7 N e 3,3 S)	10 (3.5 N e 1,5 S)
Night	0,7%	04	03 (1,1 N e 0,4 S)	01 (0,35 N e 0,15 S)
Totals	**100%**	**578**	**195,5 (34%)**	**97,5 (17%)**

Table 2:Congonhas Airport - Movements distribution among the departure routes
SOURCE: Author´s compiling from airport ATM data

Rio – São Paulo Shuttle Service Southeast direction in segregated airspace ("Tube")	30% of operations
South Region destinations Towards the south and southwest into two air ways	30% of operations
Destinations in , Southeast, North Center-west and North Regions Concentrate on north course for Campinas and Brasília – one air way	40% of operations

4.2- Alternative Operating Scenarios

Nowadays, Congonhas Airport is also limited regarding the number of direct destinations that can be reached from there, due mainly to the runway length available and the recent changes occurred on the Annex 14 ICAO. The airport can only serve destinations located within a radius of 1000 nautical miles, about 1900 km (*01).

Therefore, such connections are conducted with jet aircrafts of small and medium ranges. The definition of alternative scenarios considered this information, plus the LDN metric characteristics what most influence the noise contours: the aircraft´s type that performs the operation and the time of day when it occurs. Two distinct scenarios were developed, containing changes in schedules for operations near to the closing limits (06:00 and 23:00). They are:

4.2.1- Scenario 1

The airport stays closed for 9 hours, instead the current 7 hours, with operations starting at 07:00h (an hour later), and closing at 22:00h (an hour earlier), without any changes in the aircraft fleet: This scenario represents the major claim of the population, who rejected the airport administration´s previous proposal of closing the airport only 1 hour earlier. The movements of these 2 hours were distributed equally in the 15 remaining operation hours, because the airport´s current hourly operation limit (from 34 to 40, depending on the time of day) is lower than the physical capacity (50). Consequently, in this scenario, the strong weighting of nighttime operations of LDN metric (1 nighttime operation equivalent to 10 daytime operations) is nullified.

4.2.2-Scenario 2

The current airport´s closing period is kept in same seven hours, but with an extra restriction for jet aircrafts with higher capacity, such as Airbus 319/320, B737-NG and the EMB 170/190 families. These aircrafts were replaced in modeling for turboprop ATR 72 aircraft family during the first two and the last two hours of airport operation (from 06:00h to 08:00h and 21:00h to 23:00h). Although there is a decrease in the number of seats offered in this scenario, since they are smaller aircrafts, the passenger service does not tend to be affected because in these time limits, the "load factor" of the existing aircraft is usually lower. The difference in noise emission between these two groups of aircraft is significant, as shown in Table 3a.

Table 3a
Aircraft Noise Certification Values
Source: USA FAA-Advisory Circular 36 1H (24/04/2012)

Aircraft Model	***Engines***	***Certification Values (EPNdB)***		
		Take-off	***Sideline***	***Approach***
Boenig 737-800 (1)	CFM56-7B	88,6	95,2	96,8
ATR 72-200 (2)	PW 127	79,0	83,2	92,2
Havro HS 748 (3)		88,7	95,3	92,8
Nominal Differences (1)-(2)		09,4	08,0	04,6
Differences´ logarithmic average: 5,8 EPNdB				

The INM version 7.0, used to run all the noise contours, doesn´t work with aircraft noise certification values of ATR-72 directly. They are “emulated” by another aircraft´s values, AVRO HS 748. However, it doesn´t interfere in the analysis or the conclusions because when it´s missing an aircraft during the case design, the INM adopts the “worst case scenario” philosophy, always offering as a substitution an aircraft with similar performance characteristics, but with higher noise levels than the assumed aircraft, as can be seen at Tables 3a and 3b

Table 3b:Aircraft perform characteristics
Source: Author´s compilation from manufactures' data

	AVRO HS 748	***ATR 72-200***
Production period	1961-1988	1988-present
Maximum Take-off Weight	21092 Kg (46500 pounds)	22800 Kg (50265 pounds)
Cruise Speed	452 Km/h (244 knots)	509 Km/h (275 knots)
Service Ceiling	7620 m (25000 feet)	7620 m (25000 feet)
Payload	5136 Kg (11300 pounds)	7500 Kg (16500 pounds)
Passengers Capacity	58	68

The scenario 2 considered the work of NETJASOV. F. (2012) (*14), subdividing the four levels of mitigation measures, described in DOC 9829, in 18 subcategories, highlighting the adoption of "curfews" – replacement of aircrafts for quieter models at critical times: the use of ATR 72 aircraft to replace the current Boeing 737-NG and the Airbus family (A318, A319 and A320), at the first and the last two hours of airport´s operation.

Tables 4 and 5 present the load factor averages for the flights operated in Congonhas Airport during July 2009, one of the months that took aircraft noise monitored for this research. Table 4 presents averages for the entire month to the four main airliners, representing 95% of total. The load factor is considered low in general basis, even that there isn´t possibility to replace the fleet with quieter aircrafts to enough capacity.

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Table 4:Average load factor of aircrafts used Congonhas Airport during July, 2009
(All destinations-Covering 95% of total traffic)
(Source ANAC-Statistical data) (http://www2.anac.gov.br/Estatistica/DadosEstatisticos/dadosestatisticos.asp)

Airliner / Main Equipment	**Overall Takeoffs**	**Passengers**	**Cargo Availability**
AVIANCA (F100)	284	0,72	0,44
GOL (B737-NG)	3066	0,62	0,70
PANTANAL (ATR42)	285	0,52	0,50
TAM (A320/A319)	3063	0,63	0,55

However, Table 5 shows the averages sorted by 17 cities more served, representing 90% of movement, and only during the two last hours of daily operation time. It´s possible to observe that the average load factors of arrival flights is higher than departure flights. But half of flights operated are concentrated in only four cities (Rio, Brasilia, Belo Horizonte e Florianópolis) and their respective load factors are lower or equal to the month average. This opens an hypothesis of change the aircraft fleet for those cities and times, at least, and consequently optimize both noise generation and the operational costs for the airliners.

Only two of 19 cities showed are distant more that 900 Km from Congonhas, putting all the other cities within the optimal range for turboprop aircrafts. Turboprops also have "ceiling service" lower than turbofan aircraft and, therefore, do not compete for airspace, indirectly improving the safety. The number of operations would increase but, even so, there wouldn´t be modal competition, because the only other option for those destinations (road transportation) is far to offer the same comfort level.

Table 5:Average load factor of aircrafts used Congonhas Airport during July, 2009 (19 more served cities-Between 21:00h and 22:59h, covering 90% of total traffic) (Source ANAC)

City	Distance from CGH (Km)	Arrivals Num of flights	Arrivals Average Load Factor	Departures Num of flights	Departures Average Load Factor	Arr + Dep	Share (%)
Araçatuba	473	22	0,51	1		23	1,51%
Porto Alegre	845	37	0,77	56	0,85	93	6,11%
Brasília	881	58	0,66	101	0,89	159	10,44%
BH-Confins	499	64	0,60	89	0,76	153	10,05%
Goiânia	819	28	0,78	30	0,75	58	3,81%
Londrina	462	28	0,63	23	0,61	51	3,35%
RJ-Santos Dumont	363	113	0,52	205	0,62	318	20,88%
Campo Grande	893	57	0,70	2	0,58	59	3,87%
Florianópolis	481	62	0,70	47	0,42	109	7,16%
Salvador	1465	56	0,72	0		56	3,68%
SJ do Rio Preto	420	29	0,87	0		29	1,90%
Vitória	754	37	0,67	16	0,74	53	3,48%
São Carlos	220	1	0	0		1	0,07%
Cuiabá	1332	16	0,99	0		16	1,05%
Pres. Prudente	514	25	0,62	1	0,86	26	1,71%
Ribeirão Preto	298	5	0,67	30	0,52	35	2,30%
Marília	372	0		26		26	1,71%
Uberlândia	551	0		25		25	1,64%
Curitiba	331	9	0,96	65	0,62	74	4,86%

All the three scenarios adopted the same trajectories for both landing and take-off procedures, using the noisier flight profiles (maximum take-off weight). Each scenario has generated a new set of LDN contours, which are presented and discussed next section.

5. RESULTS AND ANALYSIS

5.1 – Current noise annoyance.

The Figure 2 shows the 62 and 72 LDN contours for the current operating configuration of Congonhas Airport. The 62 LDN contour, the outermost, covers an area of approximately 24.5 square kilometers.

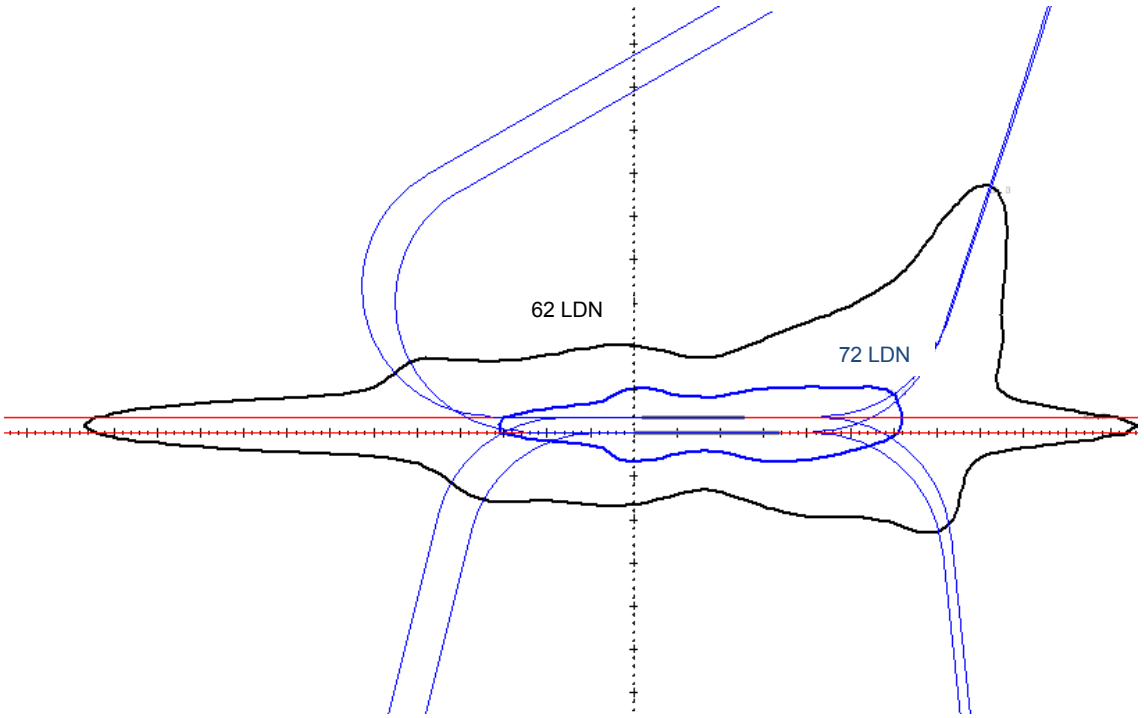


Figure 2:Noise annoyance contours (62 and 72 LDN) for current operation scenario, take-off trajectories (curve lines) and approach trajectories (strait lines) adopted

5.2 – Alternative scenario 1

Figure 3 shows the 62 and 72 LDN contours for Alternative Scenario 1, increasing the closing period to nine hours, with the redistribution of the suppressed flights in the remaining 15 hours of the day. The 62 LDN contour, the outermost, covers an area of approximately 13 square kilometers. The area decreases primarily because the nighttime noise ceases to exist in this case and, consequently, the weighting of 10 dB is no longer applied in the calculation of the noise contours, and that would have to be added to each movement occurred between 22:00 and 07:00.

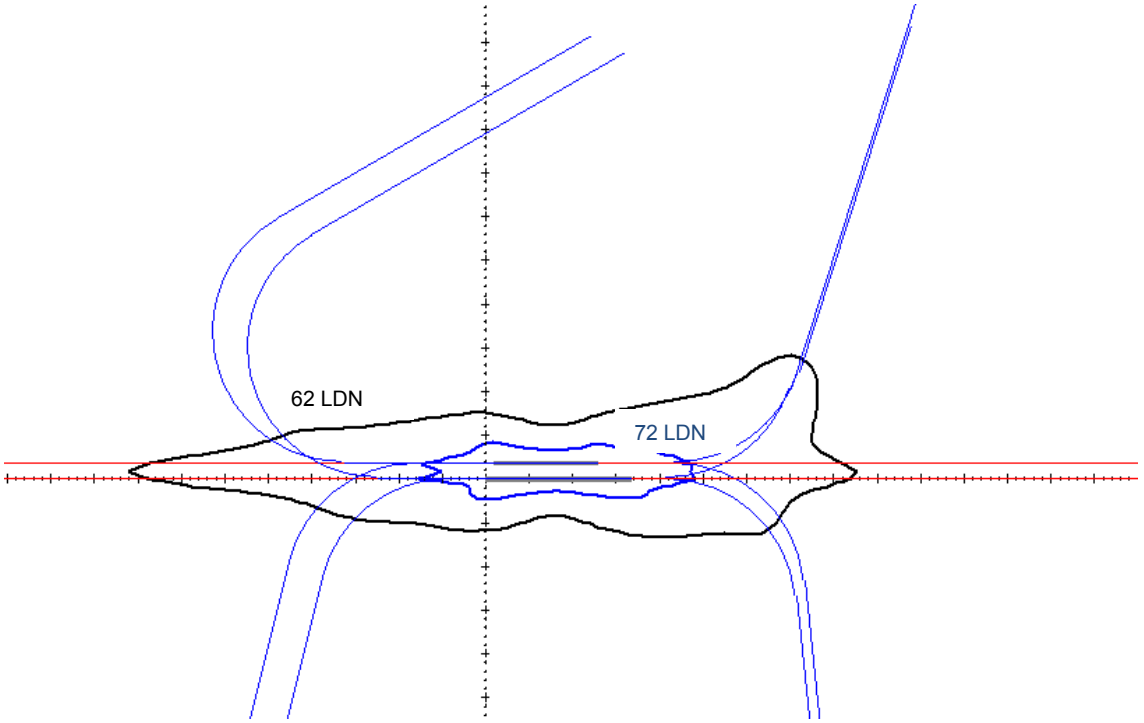


Figure 3:Noise annoyance contours (62 and 72 LDN) for alternative scenario 1, take-off trajectories (curve lines) and approach trajectories (strait lines) adopted

5.3 – Alternative Scenario 2

Figure 4 shows the 62 and 72 LDN contours for Alternative Scenario 2, with the maintenance of the current closing time, but with the jets being replaced by turboprops in the four most problematic hours (from 06:00h to 08:00h and from 21:00h to 23:00h). The 62 LDN contour, the outermost, covers an area of approximately 21.5 square kilometers, reaching almost all districts of Scenario 1. Although the average decrease of 6 dB (A) in the aircraft noise is significant among the aircrafts involved, the suggested aircraft replacement is not sufficient to override the strong influence of the 10 dB(A) weighting of the night movements in the LDN metric.

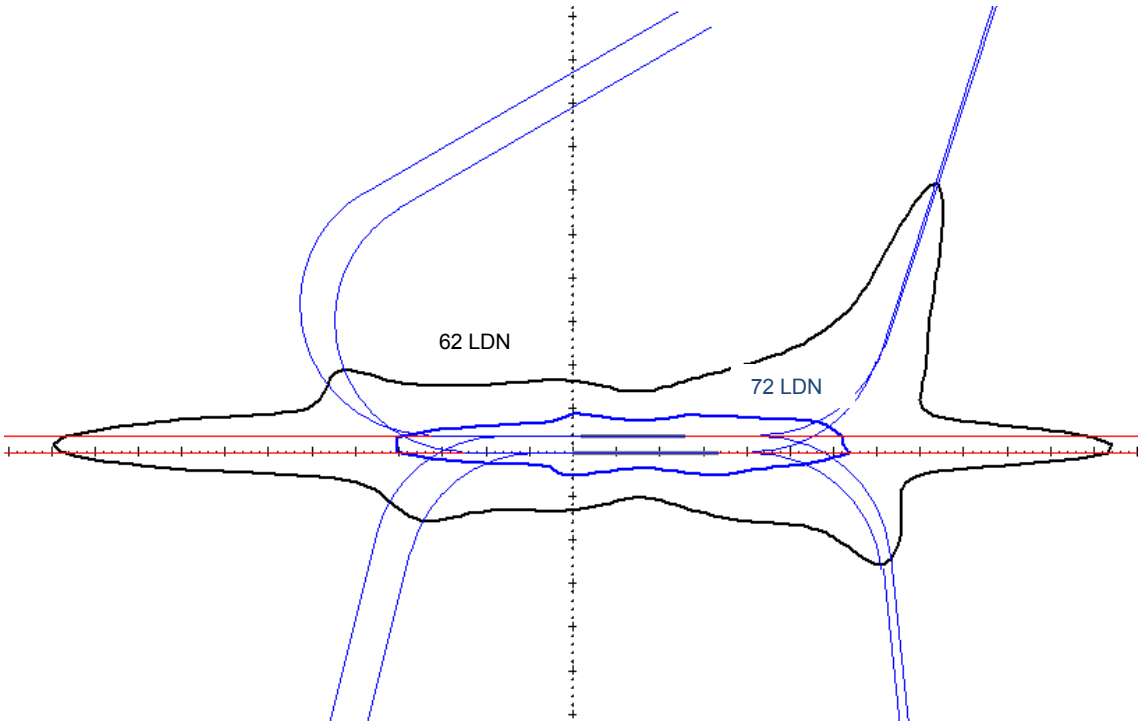


Figure 4:Noise annoyance contours (62 and 72 LDN) for alternative scenario 2, take-off trajectories (curve lines) and approach trajectories (strait lines) adopted

However, this particular configuration has a great potential to mitigate noise pollution caused by the airport, if it is evaluated together with other important information, produced by noise monitoring activities. Figures 5 and 6 present a compilation of the results from a study on total and background noise that took place in Congonhas Airport's surroundings between 2009 and 2010, when 15 locations were observed for seven consecutive days, or 168 hours. The figures show the results of total and background noise to one of four locations, where interference of the airport operation in the acoustic comfort has been confirmed. That interference occurs substantially under the main landing track axis. Table 6 summarizes the results of statistical analysis.

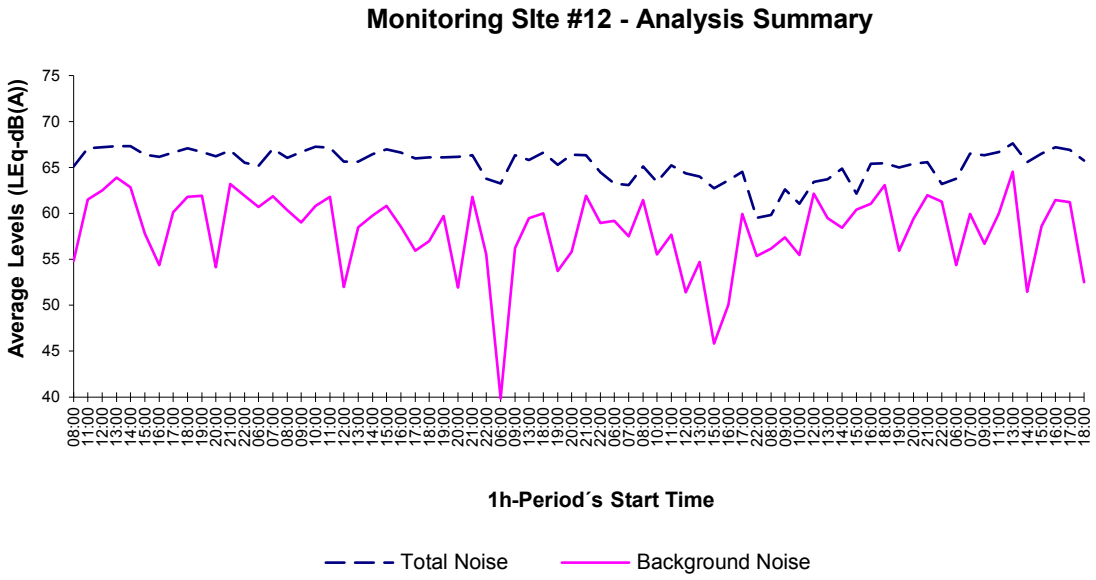


Figure 5:(Discontinuous sampling) Nominal differences between the total and background noise, calculated in 71 valid 1-hour periods, for monitoring site 12

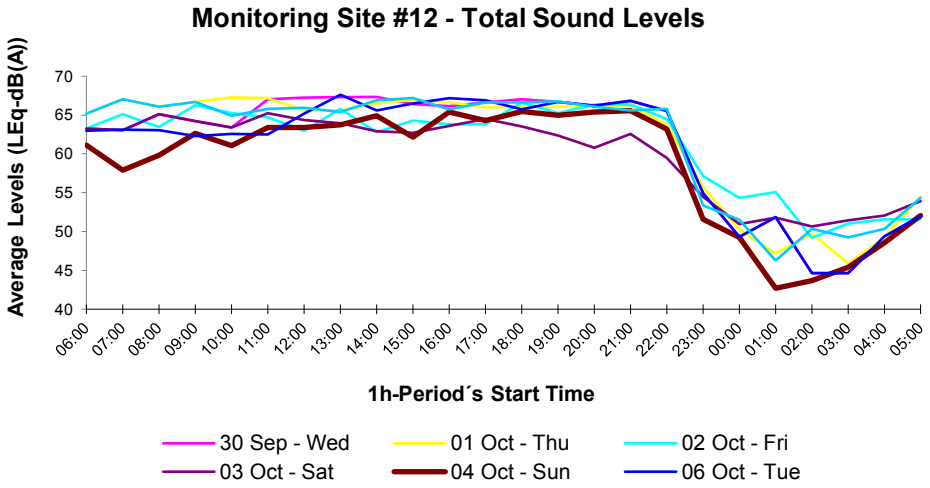


Figure 6: Behavior of the total noise average (LEq - airport + background noise) in one-hour periods throughout the monitoring site # 12

Table 6: Analysis summary for noise levels monitored at site #12

	Site #12-School
Sampling	71 hours
Total noise – all one-hour periods average	65,3 dB(A)
Minimum one-hour average / Maximum one-hour average	59,5 / 67,6 dB(A)
Number of operations per hour	15 landings
Overall background noise – one-hour average	58,1 dB(A)
Ground use characteristics	Mixed use with residential predominance
Maximum total noise averages permitted by regulation	55 dB(A) day / 50 dB(A) night
Differences average (total noise – background noise)	7,2 dB(A)
Remarks	Road traffic moderate to intense. Background noise 3 dB(A) above regulation limits

Here the aircraft noise annoyance is classified according to the Brazilian standard (ABNT, 1995) (*11) as "significant" because it presents differences between total and background noise higher than 3dB (A). This means the region evaluated by the equipment has potential to register complaints about aircraft noise, as it indeed occurs. However, the average of the non-aircraft noise is 3 dB (A) higher than the allowed noise pollution limits. This occurs because the city area where the airport belongs is naturally noisy and, somehow, there is a greater tolerance to non-aircraft noise unreported by the residents of the surrounding areas.

In Figures 5 and 6 it is observed that the largest differences among the one-hour averages of the total and background noise occur between 06:00 and 08:00, in the middle of afternoon, and between 21:00 and 23:00. That confirms the main argument of residents about the time of greatest annoyance. Therefore, if the "curfews" and the consequent change of equipment were established to these periods , as suggested in Scenario 2, the respective noise differences could be reduced up to 6 dB (A) in those periods and, therefore, would cause a positive impact on the residents perception. To the airlines point-of-view, the use of ATR-72 instead larger equipment reduces the availability of seats, but the load factor between 21:00h and 23:00h is often low in flights departing from Congonhas, independently of destination. Therefore, it is possible to the airliners to rethink their flight nets.

6. CONCLUSIONS

Despite the fact that Congonhas Airport is operating for a long time with a configuration that virtually stops the applicability of ICAO´s "Balanced Approach" concept, there is still room for mitigating aircraft noise, without increasing the current daily closure period.

However, because it is an urban and important airport for airliners and passengers, the noise annoyance simulation studies based on more usual metrics are not sufficient to understand the dynamics of what occurs at the airport surroundings. It happens, because the background noise increases in intensity more than the aircraft noise does, often "disguising" its occurrence and contributing to more tolerance from the residents, during the non-critical times. In fact, most of the population complaints do not request full airport closure, but only for 9 hours at night (from 22:00h to 07:00h)

Therefore, such studies can only be conducted if there is an effort to plan and implement a noise monitoring system on a permanent basis, as well as organize and disseminate relevant noise

measurement data in a simple and open way to all players (*16) (*08), so as provided by the regulatory agency in Brazil (ANAC) (*02).

Finally, to the Congonhas Airport in particular, the problem of non-aircraft noise, or background noise, can get worse if the city government implements an expansion of the pathways scope that are under restrictions to vehicles circulation during weekdays, in force since 1997. The consequence will be an increasing traffic on the streets and avenues that are parallel to the new restrictions areas, as additional pathways for affected vehicles, increasing even more the traffic volume and noise on streets that have either not been paved to receive this additional load. This raises the background noise and, curiously, tends to soften criticism on the aircraft noise (*06).

This paper has shown, through the analysis of the first alternative scenario, that the re-schedule only 13% daily operations, during critical periods, generates a significant effect, decreasing the annoyance area in almost 50%. It was also showed, through the second alternative scenario, the possibility to reduce aircraft noise annoyance by replacing jet aircrafts for turboprops in daily periods near to the current closing time-limits. In this case, the disturbance area was reduced by 14% compared to the current area, but the results are still significant, when there is reliable information of permanent monitoring systems.

Both scenarios are shown as alternatives to the depleted "Balanced Approach" concept, to the city airport of Sao Paulo.

7. ACKNOWLEDGMENTS

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