ENVIRONMENTAL & ECONOMICAL SOLUTION FOR SÃO PAULO CONGONHAS AIRPORT (IATA: CGH, ICAO: SBSP)

Adriana Lacerda

Daniel Fischer P. de Campos

Euler Sousa

Renato Achoa

Renato Carbonieri

A Capstone Project Submitted to Embry-Riddle Aeronautical University in Partial Fulfillment of the Requirements for the Aviation Management Certificate Program

Embry-Riddle Aeronautical University

Sao Paulo, Brazil

November 2017

ENVIRONMENTAL & ECONOMICAL SOLUTION FOR SÃO PAULO CONGONHAS AIRPORT (IATA: CGH, ICAO: SBSP)

Adriana Lacerda

Daniel Fischer P. de Campos

Euler Sousa

Renato Achoa

Renato Carbonieri

This Capstone Project was prepared and approved under the direction of the Group's Capstone Project Chair, Dr. Peter E. O'Reilly. It was submitted to Embry-Riddle Aeronautical University in partial fulfillment of the requirements for the Aviation Management Certificate Program

Capstone Project Committee:

Dr. Peter E. O'Reilly
Capstone Project Chair

Dr. Elena Navarro, Math and Research

Mr. Francisco Lyra, Brazilian Aviation Institute President

Mr. Rodrigo Freire, Azul Airlines Fuel Control Manager

Date

Acknowledgements

This Capstone Project was developed under efforts of more than the five members of this group. That is why we would like to thank our families for all the support and patience to help us through this journey, particularly the spouses and significant others.

Also, we would like to thank Fabio Campos, ERAU Regional Executive Director, for his support throughout the program course. We would like to acknowledge Dr. Peter O'Reilly for his patience and resilience, as well as his support to help us bringing this work across the finish line. We also want to thank the other instructors from Embry-Riddle that opened our minds to subjects that became part of this study.

Many thanks to all our SMEs for the valuable assistance during the researches and analysis of so many specific and complex matters.

Finally, we would like to thank our class colleagues, for their availability whenever a friendly hand was asked, reducing concerns and improving our confidence with the findings of this work.

Abstract

Group: The silence of the fans

Title: Environmental & Economical solution for São Paulo Congonhas Airport (IATA: CGH, ICAO: SBSP)

Institution: Embry-Riddle Aeronautical University

Year: 2017

The final recommendations of this Capstone Project are to reduce the usage of the aircraft APU, implement noise abatement procedures on departures and landings and use the reverse thrust at idle within São Paulo Congonhas Airport (IATA: CGH, ICAO: SBSP) operations.

The predicted, and conservative outcomes resulting from these recommendations shall impact on reducing noise, carbon emissions and aviation fuel burn, by combining in-flight and on the ground measures.

The noise produced at the airport is estimated to reduce up to 50 dB at a given procedure, which shall improve health, environment and life quality of the population that live and work nearby the airport.

In addition to the positive environmental impact, the initiatives combined shall produce total consolidated returns of near $4 Million U.S. Dollars in a 1-year term in comparison to the status-quo.

Carbon emissions reduction estimated is in the area of 18 million CO^2 per year and will also support the planned carbon mandatory compensation according to the climate agreement proposed by the United Nations for Aviation Industry, which shall take place by 2020.

Table of Contents

Chapter I

Introduction

Aircraft emissions including fuel and noise is a growing concern at the São Paulo's Congonhas Airport (IATA: CGH, ICAO: SBSP). The airport is rapidly expanding in terms of passenger traffic and average load factor. A strong growth scenario in association with poor infrastructure developments and operation restrictions has pushed Congonhas near its maximum capacity.

The intent of the project was to provide recommendations in order to reduce Congonhas's aviation related noise, in an environmentally and economically responsible way.

The expected outcomes, as result of the recommendations, includes the following:

- Fuel saving for Congonhas aircraft and ground handling operators, improving its bottom-line financial results;
- Lower noise footprint in the airport area and in its surroundings;
- Improvement on health, environment and life quality of the population that live and work nearby the airport area.

Project Definition

The study recognized the need to address the global challenge of climate change and supported IATA targets to mitigate emissions from air transport starting in 2020.

Besides looking to support the climate change positively, the study was also intimately focused in reducing fuel burn which is directly associated with noise. Therefore, all Congonhas's aircraft operators including airlines, ground handling companies and general aviation should be interested on the recommendations.

Currently, the airport does not apply any relevant noise abatement procedures and standards; neither has any noise restriction or control measures implemented “in the air” or “on the ground".

As per historic noise levels, based on data from the Brazilian Civil Aviation Secretariat (SAC), the airport operates at levels above 55 dB most of the time, a threshold at which negative effects on human health can be observed. Per SAC, high noise levels are also observed in Congonhas even when the airport is closed for flight operations, between 11:00pm and 6:00am, due to aircraft maintenance activities, for instance.

Considering the airport is located in the middle of the city, and surrounded by the most crowded area of São Paulo, there is a large number of people exposed to noise, including individuals that work at the airport, based on Brazil Census Bureau (IBGE) and Infraero - Congonhas’s administrator data bases.

Project Goals and Scope

The primary goal of this project was to research how the noise reduction in Congonhas airport can reduce fuel consumption for the aviation industry. Several methods of climbing and approach operations were analyzed. In addition, noise reduction opportunities in maintenance centers, tarmac and terminals were considered as potential opportunities for noise reduction and financial gains to the system.

Fuel saving is a key driver for most airline companies all over the world. According to IATA, in 2017, this cost represented 17, 4% of total operating cost for an airline. This cost could be higher if the barrel of crude oil had the same value of 2008, when it represented 35.7% of the total airline costs by that time.

Airport noise reduction is a worldwide trend. The Brazilian aviation industry has been a good candidate for a noise reduction program for some time. The economic environment is fully related to how airports apply noise abatement measures and countries with higher GDP per capita are more likely to apply these measures (Ganic et al, 2016). São Paulo City is the largest city in Brazil and its airport, located in the middle of the city, was a perfect scenario for this analysis.

Another goal of this project was to explore ways to increase life quality of population that lives and works around the airport. A good way to achieve this was to involve government agencies.

Recently, the Brazilian Government decided to privatize the airport and, with a new management and capital structure, this has opened up the possibility for change at the airport. The new operator is expected to make large investments in new solutions, as it happened recently, in other privatized airports in Brazil.

Other indirect achievements were expected with this study. Noise barriers in the maintenance area could help airlines to perform tasks in this airport which are currently not allowed, such as run-up tests, ram air turbine tests and borescope inspections. New procedures would also help air traffic controllers (ATC) in its workload and would help airline companies to battle for having additional slots at this airport.

Regarding the scope of the project, it was separated in two main areas: ground activities and flight activities.

- As per ground activities (new assets), the intention was to propose:
    - Implementation of ground power units at all aircraft parking positions (GPU);

    - Implementation of air conditioner units at all aircraft parking positions (ACU).
- Ground activities (new standards operational procedures) proposals were:
    - Time limits for the use of Auxiliary Power Unit (APU);
        - After aircraft parking procedure;
        - Before aircraft engine start up and pushback procedures.
    - Time limits for the use of brake fans (Airbus operators only);
    - New standard procedures for the use of thrust reverse (idle thrust) during the DRY RUNWAY (RWY) only. (NOTE: this procedure does not influence the landing distance required when the RWY is DRY).
- Flight activities (new standards instrument departure procedures) proposals:
    - New route design;
    - Implementation of ICAO DOC 8168 – NADP1 - Noise Abatement Departure Procedure type 1.
- Flight activities (new instrument approach and landing procedures) proposals:
    - Redesign of RNAV (GNSS) approaches, increasing the flight path angle of final approach. (NOTE: to be used under visual approaches).

Definitions of Terms

AMBIENT NOISE: The combination of all noise sources that occur, typically described for a specific environment, location, and/or period of time.

ATIS: Automatic Terminal Information Service. Automatically recorded message transmitted on a particular frequency, containing current weather conditions, QNH setting, active runways, etc., provided at the major airports.

BENEFITED RECEPTOR: All receptors, both impacted and non-impacted, that receive a noise level reduction of 5 dB (A) or more through placement of a noise abatement measure.

DECIBEL (dB): The logarithmic unit for measuring the ratio of a physical quantity relative to a specified or implied reference level.

FINAL: Final Approach. One of the many words describing the approach segments. The part of a landing sequence or aerodrome circuit procedure in which the aircraft has made its final turn and is inbound to the active runway.

GO-AROUND: Balked approach, when the aircraft climbs away from the runway during the approach, to either start the approach again, or proceed to the ALTERNATE AIRPORT.

GS: Glideslope. Vertical guidance, part of an ILS, establishing the safe glide path to a runway. A standard ILS glideslope is 3 degrees.

IATA: International Air Transport Association.

ICAO: International Civil Aviation Organization.

IFR: Instrument Flight Rules prescribed for the operation of aircraft in instrument meteorological conditions.

ILS: Instrument Landing System. Consists of the localizer, the glideslope and marker radio beacons (Outer, Middle, Inner). It provides horizontal and vertical guidance for the approach.

METAR: Aviation routine weather report. Format for shorthand weather information reporting using a standardized set of codes and abbreviations (for example:

BKN broken clouds, OVC overcast, CAVOK ceiling and visibility okay, etc.) Acronym possibly comes from the French “Météorologie Aviation Régulière” (routine aviation weather).

NOISE: Any unwanted sound.

NOISE ABATEMENT: Type of attenuation, such as an earthen berm or solid-mass wall, used to reduce traffic noise levels.

NOISE CONTOUR: A linear representation of equal noise levels, similar to elevation contour lines on a topographic map.

NOISE LEVEL REDUCTION: The reduction in noise levels accounting for all known noise sources and attenuating measures.

NOISE SENSITIVE AREA: A geographically limited area in which noise sensitive land uses exist that are, or may be exposed to, similar noise sources.

STAR: Standard Terminal Arrival Route, for inbound IFR traffic.

List of Acronyms

ABEAR: Airlines Brazilian Association

ACFT: Aircraft

ACMG: Airline Cost Management Group

ACU: Air Conditioning Unit

AIS: Aeronautical Information System

ALP: Airport Layout Plan

ALS: Approach Lighting System

ANAC: Agência Nacional de Aviação Civil (Brasil)

APP: Approach

ASDA: Accelerate Stop Distance Available

ASU: Air Starter Unit

ATC: Air Traffic Control

ATIS: Automated Terminal Information Service

ATMS: Advanced Traffic Management System

ATS: Air Traffic Services

ATC: Air Traffic Control

ATM: Air Traffic Management

CAEP: Committee on Aviation Environmental Protection

CDA: Continuous Descent Approach

CGH: São Paulo International Airport (IATA)

CGNA: Air Navigation Management Center

CTA: Control Area

CWY: Clearway

D-ATIS: Digital - Automatic Terminal Information Service

DA: Decision Altitude/Decision Height

DA/H: Decision Altitude/Height

DB: Database

dB: Decibel

DH: Decision Height

DME: Distance Measuring Equipment

DNL: Day-Night Equivalent Sound Level

DP: Departure Procedures

EASA: European Aviation Safety Agency

EDMS: Emissions and Dispersion Modeling System

EFB: Electronic Flight Bag

EFIS: Electronic Flight Information Systems

EPNdB: Effective Perceived Noise Level in Decibels

ERAU: Embry-Riddle Aeronautical University

ETA: Estimated Time of Arrival

FAA: Federal Aviation Administration

GDP: Gross Domestic Product

GNSS: Global Navigation Satellite System

GPS: Global Positioning System

GPU: Ground Power Unit

IATA: International Air Transport Association

IBGE: Brazil Census Bureau

ICAO: International Civil Aviation Organization

ILS: Instrument Landing System

KIAS: Knots Indicated Airspeed

LDN: Day-Night Average Sound level

MAP: Missed Approach Point

METAR: Aviation Routine Weather Report

MHz: Megahertz

NADP: Noise Abatement Departure Procedure

NM: Nautical Mile

OSHA: Occupational Safety and Health Administration

PANS: Procedures for Air Navigation Services

PAPI: Precision Approach Path Indicator

PIC: Pilot in Command

RNAV: Area Navigation

RNP: Required Navigation Performance

ROTAER: Air Routes Auxiliary Publication

RWY: Runway

SAC: Brazilian Civil Aviation Secretariat

SARP: Standards and Recommended Practices

SBSP: São Paulo Congonhas International Airport (ICAO)

SID: Standard Instrument Departure

SOP: Standard Operating Procedures

STAR: Standard Terminal Arrival Route

TAF: Terminal Area Forecast

TWY: Taxiway

VASI: Visual Approach Slope Indicator

VFR: Visual Flight Rules

VMC: Visual Meteorological Conditions

INTENTIONALLY LEFT BLANK

Chapter II

Review of Relevant Literature

The intent of the project was to provide recommendations to reduce Congonhas's aviation related noise, in an environmentally and economically responsible way.

The selected literature below covers key matters within the project topic including:

- Congonhas airport characteristics,
- Aircraft emissions impact to the airline and the environment,
- Noise abatement procedures in flight and at the ground, and,
- The aviation fuel dynamic in Brazil.

Congonhas Airport

Congonhas Airport is located in São Paulo City, Brazil, the most populous city in the Southern Hemisphere (United Nations, 2016).

The airport is located 5 miles from São Paulo's downtown and is therefore, favored over the larger, but more distant Guarulhos International Airport. Congonhas is restricted to 40 operations per hour. It is also closed for departures and landings between 11pm and 6am (ROTAER, 2017). Currently, it only serves domestic destinations (CGNA, 2017).

Table 1. Congonhas Airport in Numbers.

Airport Site	1.647.000 m2
Aircraft Site Apron	77.321 m2
Runway Dimensions	1640 x 45 m
Auxiliary Runway Dimensions	1345 x 45 m
Passenger Demand	20.816.957
Cargo Demand	49.230.804 kg
Passenger Terminal Area	64.579 m2
Passenger Boarding Bridge (PBB)	12 positions
Commercial Aircraft Parking Positions	29 positions

Source. Infraero & Congonhas Airport Diagram 2017.

Congonhas was built in the 1930s. Originally, it was away from the city. However, the city did grow around it. The airfield is now a thin strip of green surrounded by high-rises (Allianz Travel Insurance, 2017).

As you can see on Figure 1, the airport is located in the middle of the city. It is surrounded by the most crowded area of São Paulo.

Figure 1. Congonhas Airport aerial view.

Aircraft Noise

Although fewer people are exposed to air traffic noise than that from road or rail, it is reported to cause greater annoyance (Guarinoni et al., 2012; ISO, 2016; Münzel et al., 2014). Figure 2 below, reviews the percentage of people highly annoyed by aircraft, road and rail noise. The curves were derived for adults based on surveys (26 for aircraft noise, 19 for road noise, and 8 for railways noise) distributed over 11 countries. (Adapted from Münzel et al., 2014)

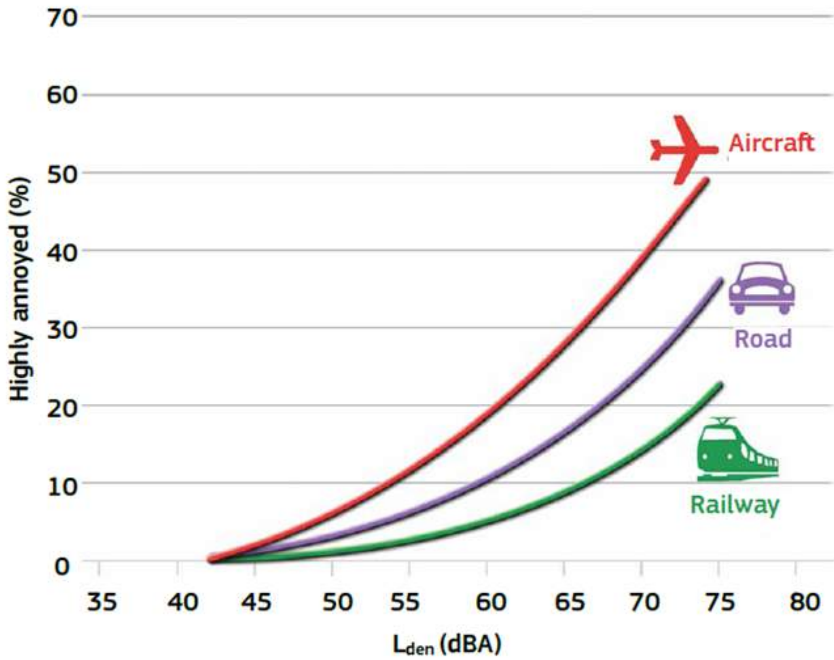

Figure 2. Percentage of People Highly Annoyed by Aircraft, Road and Rail Noise.

The main source of airport noise is, actually, from the aircraft itself, which generates noise on the ground while parked, while taxiing, during run-up, take-off, flight and landing.

Noise originates from three major sources: (a) aerodynamic noise (due to the airflow around the main body of the aircraft, increasing with speed and at low altitudes), (b) engine/mechanical noise (due to the jet engines, which predominates during take-off and climb), and (c) noise from aircraft systems (from the auxiliary power unit, which is used to start the main engines and provide power while the aircraft is on the ground). (European Commission, 2017)

Balance Approach for Noise Reduction

It is necessary to bear in mind the philosophy of continuously improving the ways of alleviating the noise exposure in a consensual way, namely the "Balanced Approach" concept, prescribed by the ICAO resolution A33-7, voted in October 2001, which was reaffirmed in 2007. (ICAO 2007)

In the Balanced Approach, the ICAO has defined four key elements that can be used to achieve an effective reduction in aircraft noise without compromising safety standards:

- Noise reduction at source. This included the use of quieter aircraft and the implementation of noise reducing measures on the engines, wings and landing gear of existing aircraft fleets.
- Local measures in the vicinity of the airport. These consisted of a land-use plan tailored to noise protection zones, passive noise control, and noise based take-off and landing charges.
- Noise abatement operational procedures in the air and on the ground. The range of innovative flight procedures being tested at various airports included the continuous descent approach, as well as satellite-supported approach procedures or measures that help to cut engine use on the ground. Both landing and take-off operations are critical from a noise point of view.
- Noise-based operating restrictions. These were any noise-related actions that limit or reduce an aircraft's access to an airport.

An important subject regarding the Balanced Approach to Aircraft Noise Management is the reduction of noise at its source. Noise has been controlled, somewhat, since the 1970s by the setting of noise limits for aircraft in the form Standards and Recommended Practices (SARPs) contained in Annex 16 to the Convention on International Civil Aviation. This continues to be the case and improving over the years from Chapter 2 to Chapter 14, as shows in Figure 3. (ICAO ANXEX 16 - 2009)

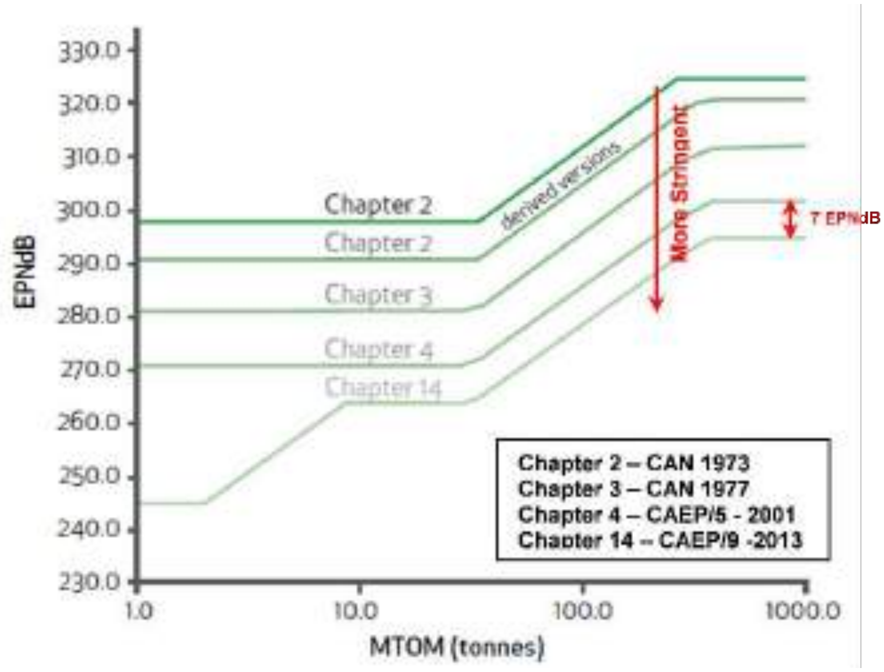

Figure 3. The Progression of the ICAO Noise Standard.

In February 2013, the CAEP/9 (Committee on Aviation Environmental Protection) meeting recommended an amendment to Annex 16, Volume I involving an increase in stringency of 7 EPNdB (cumulative) relative to the current Chapter 4 levels. In 2014, the ICAO Council adopted the new Chapter 14 noise standard for jet and propeller-driven aircraft (Doc 10012 CAEP/9 - 2014).

This new and more stringent standard is expected to be the pillar ICAO Standard for subsonic jet and propeller-driven aircraft noise for the coming years. It is applicable to new aircraft types submitted for certification on or after 31 December 2017, and on or after 31 December 2020 for aircraft less than 55 tones in mass. (ICAO Environment 2013)

This work was separated in two main areas: ground activities and flight activities. Part of this work, and continuing with the concept of the Balanced Approach, aims to establish specific operational procedures at Congonhas Airport (SBSP) with regard to the selection and development of Noise Abatement Procedures (for departure and approach) designed according to the guidance in PANS-OPS, Volume I, Part V, Chapter 3.

Environmental Impacts for Residential Real Estate

Airport noise is considered a Detrimental Condition (DC) and a cause of reduced market value to properties (Randall Bell, 2001), as it is defined as a permanent externality or neighborhood condition. According to Bell (2001), noise is any unwanted sound. Using this definition, the sound emanating from the aircraft is considered noise to a large part of the population. This noise is translated to DC and, consequently, to sales prices.

Besides noise, poor air quality can increase adverse short- and long-term effects on human health (Schwartz, 1997; Rückerl, 2011). Airports can be considered big pollutant emitters because of its concentration of pollutants coming from the aircraft (Amato, 2010). In addition, it can affect air quality near it (Unal, 2005). D. Hite, W. Chern, F. Hitzhusen and A. Randall (2001) provided several effects of environmental contamination on real state, resulting on sales price reduction. Air quality contamination, if considered a DC, may effect on property values as well.

Airport Disturbance on Nearby Communities

Upham (2004) stated the importance of community tolerances with airports impacts, as part of the condition of its operation. “Environmental capacity is constituted of social as well as physical factors, in the sense that many of its component limits are politically mediated” (Upham, 2003, p. 150). The community that lives close to Congonhas Airport (CGH, Brazil) have created an association of residents “Associação dos Moradores do Entorno do Aeroporto de

Congonhas" (AMEA). This Association has as a basic principle the defense of their properties in its tangibles and intangible aspects.

There is also a social approach regarding airport noises and the maximum level of sound exposure according to the limits imposed by national regulations (J. Cidell, 2008). Although Guski (1999) stated that there is no correlation between noise level and noise annoyance. Congonhas Airports' close communities have been facing noise-related dissatisfaction when noise has exceeded imposed national limits. This has increased the number of formal complaints from AMEA (Local news g1.globo Link, 2017).

As per Stallen (1999), "understanding noise-induced annoyance requires the understanding of judgmental, attitudinal and, thus, social processes" (p. 69) Stallen has also developed a framework as a form of psychological stress, based on the 1966 psychological stress theory of Lazarus. Stallen created a relationship between sound exposure and annoyance, as shown on Figure 4 below:

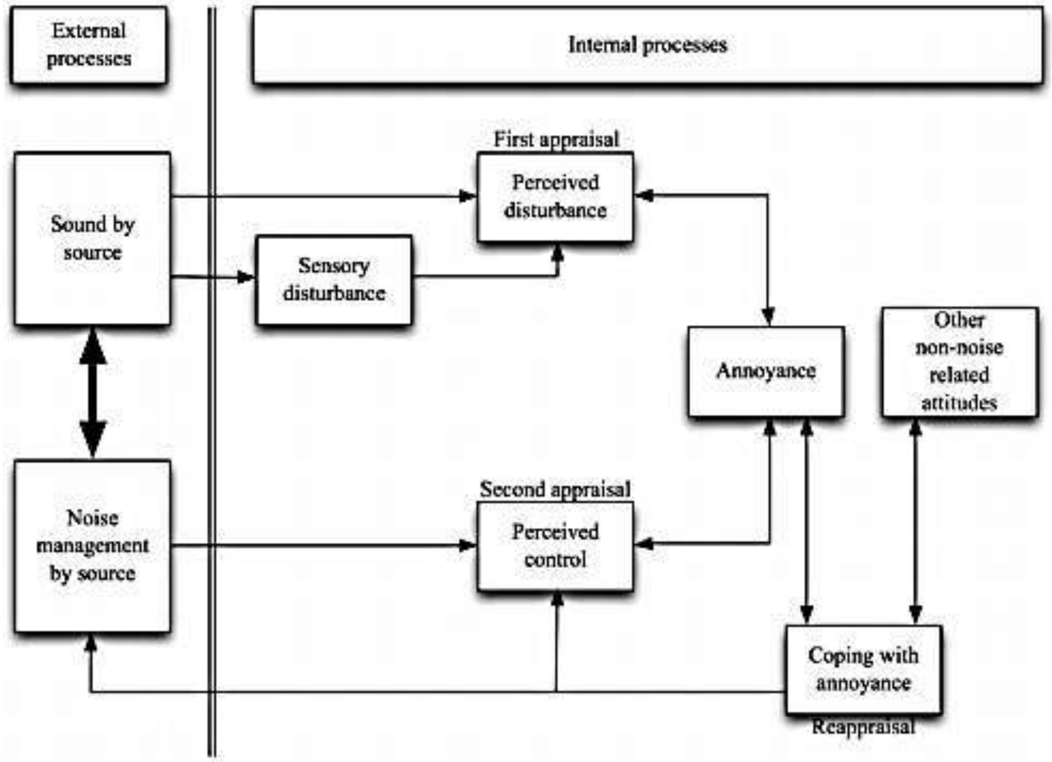

Figure 4. Stallen's Noise Annoyance Framework.

Noise disturbances can cause harm to individuals' performances, in terms of executing actions, developing mental processes, and even when trying to rest. That is why AMEA is advocating efforts to improve life quality of its residents, with combined actions with Congonhas Airport authorities. Maris (2017) stated that "if the exposed has little control over the source (of noise), or little trust in the source (of noise), the perceived coping resources will be reduced and psychological stress will arrive" (p. 2001).

Fuel Impact on Airline Operating Cost

- Airline operating costs consider both flight and ground costs that are resulted from the operations of an aircraft. Total airline costs can be allocated into four main airline operations: flying aircraft comprise activities related to flight operations, aircraft ownership, fuel and navigation fees..

- Maintaining an aircraft includes activities related to maintenance and overhaul.
- Servicing aircraft consists of ground operations expenses such as station and airport charges.
- Running the airline involves cross-divisional activities, such as general and administration, reservations, tickets, sales & promotion and IT. (ACMG, 2015)

Airline cost structure can be better accessed with the results of a survey done by IATA Airline Operational Cost Task Force. This survey reported a consolidated response of 59 airlines on airline cost assumption, representing 51% of the share and 47% of the passengers carried worldwide.

Figure 5 herein below represents the total airline cost distribution, compiled by the survey results.

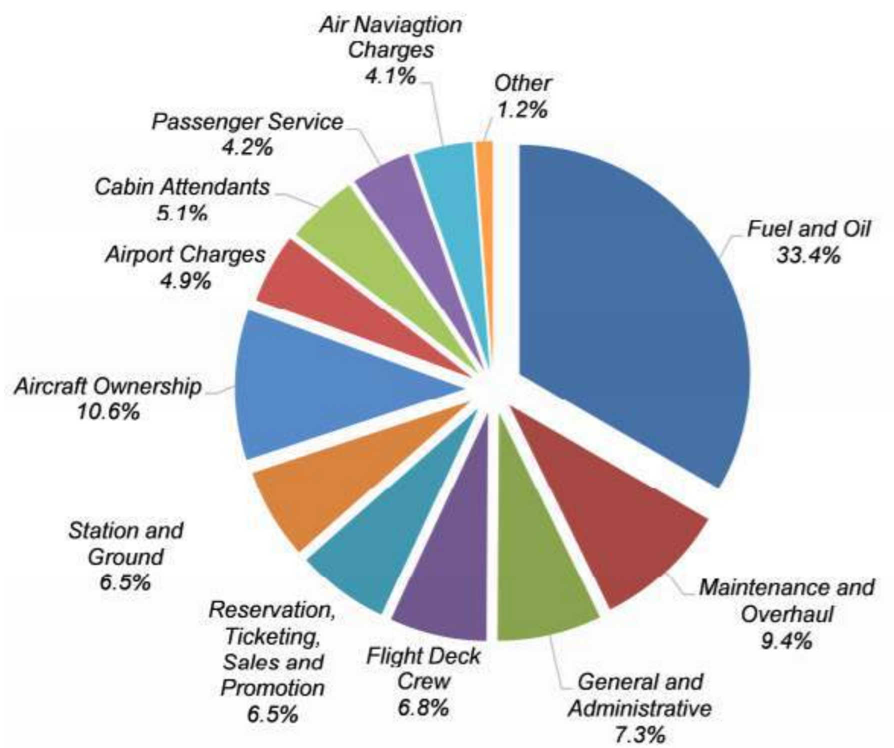

Figure 5. Distribution of Total Airline Cost

The proportion of fuel and oil expenses in total operating expenses ranged between 20% and 40%, with the average of 33.4%. Therefore, fuel costs remain a major concern of airlines, which have little control over its price. Therefore, an effective way of reducing airline operating costs is by reducing fuel consumption.

Fuel saving of just one minute on each flight can save direct fuel costs of over $1 billion each year. In addition, it can significantly reduce environmental emissions, including carbon and noise. A different way to look at this is considering each 1% improvement in fuel efficiency across the aviation industry can lower the total fuel bill by around $700 million per year (IATA, 2017).

Aviation Fuel Economics in Brazil

With oil prices higher than during most of 2016 as illustrated in Figure 6 below (Platts, 2017), the market expectation is for oil prices to average around $55 per barrel in 2017. Airlines will most likely face higher jet fuel costs in the following years, as the world political climate continues deteriorating within North Korea and the Middle East situation.

Figure 6. Jet Fuel and Crude Oil Price ($/barrel).

Fuel costs should be manageable for airlines that have done a good job of hedging their fuel costs, and for those that mostly generate their revenue in U.S. dollars or operate in mature markets where airlines can claw back much of the fuel cost increase through higher fares. However, the cost burden could be heavier for airlines based in countries whose currencies have depreciated against the U.S. dollar, or markets that have been experiencing yield pressures and that have somewhat a peculiar fuel pricing policy.

That is in fact the case for Brazil, where fuel prices are 30% more expensive than Europe and the U.S (Royal Dutch Shell, 2017). In Brazil, fuel costs are responsible for 40% of the cost of flying, while it averages about 35% in the rest of the world. Reducing the impact of fuel costs has become the number one challenge local regulators must overcome (ABEAR Panorama 2016).

The reason for this high fuel prices in Brazil is largely because the state-controlled oil company, Petrobras, still charges a heavy “import fee” (Sanovicz, ABEAR 2014). This occurs even though more than 85% of the fuel consumed in Brazil nowadays is produced and refined locally. The pricing structure is set up as if 100% of the fuel were imported and this adds artificial expenses to the cost of fuel, such as an "imaginary shipping cost of fuel from Texas to Brazil," said Hemant Mistry, a director at the IATA.

Petrobras, which holds a near monopoly in the market, said its jet fuel formula was "based on the parameters of the international market with oscillations lower or higher". The calculation behind the formula is not made public, which is a major concern, according to IATA.

Jet Aircraft Noise Behavior

One of the reasons for an increase in the number of people affected by noise is the rise of residential areas located closer to airports. The community noise does not only include the aircraft emissions, but also other sources, such as road traffic. Actually, the airport-side residents are also exposed to these other sources, the noise of which may be higher than the one produced by the aircraft, at least in terms of equivalent acoustic energy. (ICAO Doc 9829 – 2008)

The noise produced by aircraft was not a major issue before the early 1960's, as shown in Figure 7, when the use of jet-planes started to grow. Despite considerable reductions over the years in aircraft noise, the combined efforts of aircraft manufacturers and engines, airlines, airports, and aviation managers to extensively reduce the impact of noise on airport communities, airport noise remains a critical public policy issue. Besides, given the expected increase in air traffic and airport operations over the coming decades, noise will continue to be a source of divergence. Even with the same level of exposure to aircraft noise, the degree of satisfaction among individuals varies. (ICAO DOC 9888)

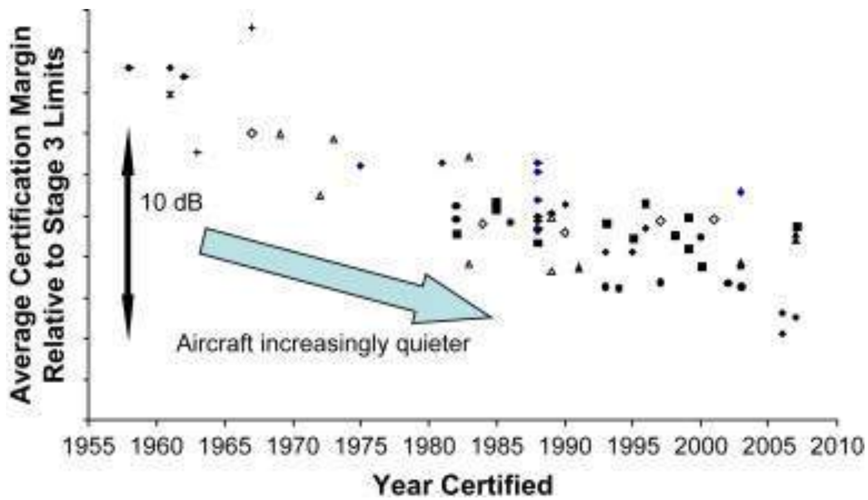

Figure 7. Certification noise levels of jet aircraft.

Flight Activities for Noise Abatement

As Congonhas airport stays in the middle of downtown the recommended procedure is the ICAO noise abatement departure procedure “close-in”. This procedure intends to reduce noise levels close to the airport. It involves a thrust cutback at or above a prescribed minimum altitude (800 ft.) and delaying the flaps/slats retraction no later than the prescribed maximum altitude (3000 ft.). At the prescribed maximum altitude, acceleration and flaps/slats retraction are performed according to standard schedule while maintaining a positive rate of climb and then completing the transition to normal en-route climb procedures. (ICAO DOC 8168 – 2016)

Continuous Descent Approach (CDA)

An approach with minimum or no recourse to level segments below typically 7000ft above field elevation (AFE). It should be combined with appropriate flap/gear deployment schedule to avoid that additional airframe noise eliminates the noise reduction obtained by flying higher. Nonetheless, the potential is quite significant, as 2 dB (A) per 1000 ft. increase of the minimum interception altitude can be expected over the previously mentioned area. (ICAO DOC 9931 – 2010)

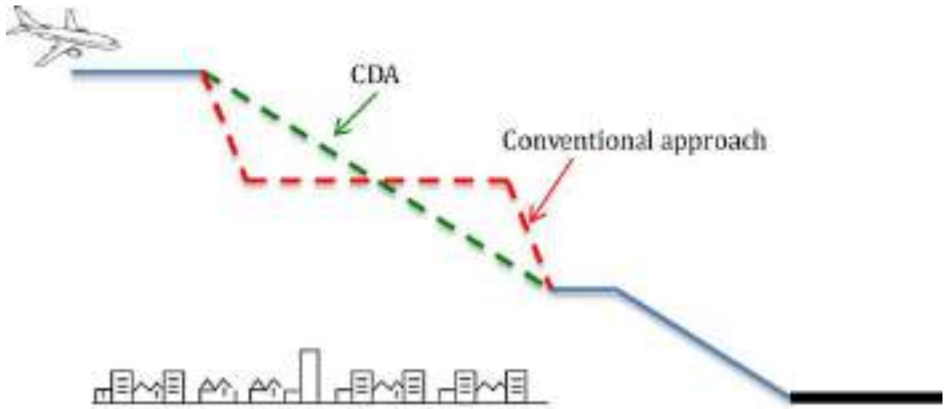

Figure 8. CDA vs. conventional approach.

For the approach procedure the mitigation proposed was to design an approach profile where the engine power being close to its minimum during the approach phase, decreasing the noise levels means to minimize the airflow influence around the high-lift devices (flaps, slats) and landing gear, which are extended in this flight phase. Two procedures can be applied to reduce noise during the approach and landing, A STEEP APRROACH that allows a higher fly-over, as well as a faster direct approach.

Ground Activities for Noise Abatement

As found in the ICAO Noise Abatement Research (ICAO, 2007), there are five areas for noise abatement in ground management:

- Hush houses and engine run up management (location/aircraft orientation, time of day, maximum thrust level);
- APU management;
- Taxi and queue management;

- Towing;
- Taxi power control (Taxi with less than all engines operating).

Auxiliary Power Units (APUs) are small engines and generators in the tail of an aircraft that are used to deliver electrical power and cabin conditioning while on the ground (Girvin 2009). In order to reduce noise, APU usage conditions are specified in airport procedures to limit their use and supply alternative systems for them to use whilst on the ground including Fixed Electrical Ground Power (FEGP) and Pre Conditioned Air (PCA). This is essentially plugging aircraft into the mains electrical supply while they are parked. This procedure leads to a reduction in ground noise. (Girvin 2009)

Summary

Noise in Congonhas airport is considered a Detrimental Condition (Local news g1.globo Link, 2017). In addition, other environment issues are associated to any airport in the world, such as: poor air quality, due to concentration of pollutants coming from aircraft (Schwartz, 1997; Rückerl, 2011). Besides the environmental problems, economic and social impacts are also observed near an airport with big traffic, as Congonhas. Buildings around the airport are less expensive when compared to non-airport neighborhoods (A. Randall, 2001). Communities around the airport are always impacted by aircraft noise. It is normal to have discussions involving public agencies and for these communities to find a common and better way for everyone.

Aircraft fuel is the main cost of an airline company. Any reduction in jet fuel consumption can provide large scale saving. According to IATA, if every flight in the world reduces its duration by one minute, it can save $1 billion dollars in a year (IATA, 2017). In addition, fuel saving represents less carbon emissions and reduced noises.

Brazilian airlines have additional costs related to fuel: state taxes, which are included in the final fuel price (Sanovicz, ABEAR 2014). Petrobras, the state-owned company that holds exclusive permission to refine the fuel, has its own unique way of pricing jet fuel. This method, unfortunately, is not public. These factors make Brazil a country with a good opportunity of reducing fuel consumptions and, consequently, carbon emission, as well as, achieving noise reductions.

Activities related to noise reduction can be used in all steps of a flight and on ground (ICAO, 2007). Modern aircraft have lower problems related with noise in comparison with aged jets. ICAO provide a noise classification for aircraft. In addition to aircraft classification, the UN-related agency defined four big steps to achieve an effective noise reduction in airports: at source, airport vicinity, operational procedures in the air and in the ground and operational restrictions.

INTENTIONALLY LEFT BLANK

Chapter III

Methodology

The study was designed to consider the group's experience and knowledge about the Congonhas airport and the city it is located in, Sao Paulo. The initial goal was to consider information from neighborhood associations and the comparison of Congonhas with European airports practices regarding noise policies and fuel efficiency, as it can be observed on the references used.

Although Congonhas is one of the busiest airport in Brazil, it does not perform global best practices regarding noise abatement. This raised the objective to propose implementing new ground and in-flight procedures addressing this matter. The methodology of how the authors designed the procedures was based on the Annex 16 of ICAO, whereas is replicated by the Brazilian regulation RBAC 36, regarding noise information and regulation for aircraft departure and arrival. The recommended solutions to reduce noise were based on the ICAO DOC 8168 in order to propose a new procedure's design.

Regarding fuel savings, the authors have used the Brazilian airlines´ historic data to understand the size of flight operations, combined with fuel consumption and maintenance data from three largest aircraft manufacturers Boeing, Airbus and Embraer.

Experimental Design

The problem researched was related to fuel and noise emissions from Congonhas Airport. A few studies related to this issue were also addressed which provided a diagnostic on this matter.

The challenges faced during this study were also expected considering other article's findings and lessons learned, as per "Balanced Approach (2015)". The article had already discussed alternative scenarios for flight operations, according to the challenge on applying ICAO concepts.

Hypothesis raised during the outcome session were conducted using financial analysis, such as the selection between GPU and electrical ground units replacing the APU. One depended on the airline's willingness to invest, as the other focused on airport (or governmental) support, respectively.

The data used for this study was gathered with internet research, face-to-face interviews with several "Subject Matter Experts" and the authors' professional experience. The proposed recommendations were validated through published researches and the outcomes were calculated using real airline performance data.

To evaluate the noise, a performance software from Airbus was used to measure the sounds produced by an A320 at defined noise pick-up points during a typical flight. The null hypothesis was having all the sounds within regular limits.

Data Source

The authors did split the work into two parts in order to develop the research: ground operations and in-flight operations. ANAC academic papers, aircraft manufactures documentation and experiment collection were considered as sources for supporting the research.

Data used for analysis and referenced in this study was acquired from a set of primary (collected through own experiment) and secondary (collected from existing data sources) sources in the form of qualitative and quantitative data. Measurement techniques, test procedures, and supporting documentation related to the noise certification plan were also analyzed.

The documentation used was published under Annex 16 of the Chicago Convention. In Brazil, noise certification was addressed by RBAC 36, which fully adopted the FAR 36 (Federal Aviation Regulations Part 36).

For ground operations, the authors used technical publications data from aircraft manufactures such as Boeing, Airbus and Embraer to verify the noise produced by the engines and the APU, including references on noise measurement devices.

For flight operations, in addition to all the documentation from the aircraft manufacturers, the authors have also used the Airbus Performance Engineering Program (PEP) software as data source to simulate aircraft operations with defining their vertical and horizontal trajectories.

However, for APU and brake cooling fan noise data, the authors used academic papers to prove the noise reduction when the aircraft is not using those system. The exactly quantity mitigated by this action, the authors strongly recommend further and deep analysis.

Data Collection

The collection of data considered the following sources:

- Congonhas neighborhood associations: by calling representatives to better access the issue.
- Number of people within the area of noise health risk: by consulting with Infraero, the airport administrator and through other official government sources, such as the IBGE (Brazil Census Bureau).

- Congonhas noise footprint: noise levels history collected from previous research studies (Fabio Scatolini, 2016), current noise data (aircraft and background related noise) from measures using Airbus Performance Engineering Program (PEP) indicating the noise level at certain selected locations nearby the airport, certification noise levels from the aircraft OEM's manuals and other research references.
- Congonhas fuel use: by contacting ABEAR airlines and asking what is the typical fuel burn during non-flight activities (APU and GPU usage) and consulting the different OEM's aircraft performance manuals to understand typical fuel burn per aircraft type in an airport field scenario characteristics such as Congonhas.
- Aircraft operation data in Congonhas: by using Diio Mi software trial license, which is a market intelligence tool that collects data from several different sources per demand. In our case, the software pulled data from Innovata, which is a SRS (Schedule Reference Service) provider. The authors asked the system to pull all Origin and Destination Traffic Data at Congonhas airport, sorted by airline, aircraft, seat count, load factors and flight times considering 2016 actuals and 2017 prediction.
- ATC (Air Traffic Control) charts: The authors have collected all Congonhas related charts from the ABEAR airlines including standard terminal arrival charts, departure and approach procedures and airport diagrams.
- Automotive fleet quantity that operates inside the airport area: data collected with ABEAR airlines and aircraft handling companies.

Analysis

The main analysis of the study was performed using empirical experience of the group members, for operational and financial concerns. All noise abatement data gathered for this study came from aviation official entities such as: ANAC, ICAO, IATA, ABEAR and AIRBUS.

Initiatives regarding fuel saving and noise abatement were raised in order to achieve the proposed outcomes. Airbus PEP was used to measure noise around airport, by analyzing the take-off and landing phases based on the A320 aircraft. The Airbus software uses a specific method considering the aircraft certification process for distributing decibels in take-off, cruise, descent and landing phases by geographic positions, leading to a decibel measurement around several pick-up points within the Congonhas Airport area.

Regarding fuel savings, the research was performed considering two initiatives: ground and in-flight activities. For the first one, ROI indicated the results from purchasing Ground Power Units (GPUs) both for jet bridges and for tarmac positions:

ROI = (S/I) / I

Where:

S: Saving and incomes from purchasing new electrical devices instead of using fuel related equipment, such as aircraft power unit.

I: Investment for purchasing GPUs

APU data: Airbus (FCOM)

The result allowed a profit comparison between the GPU purchase and the use of APUs. In addition to ground activities, in-flight analysis was performed by calculating operational performance in take-off and landing phases of the flight, considering the Airbus A320 as the default aircraft for the analysis.

With the proposed new procedures, according to the aircraft manual, it was possible to analyze the increase or decrease of fuel consumption in the new procedures. The authors have projected the savings to all commercial flights in the Sao Paulo Congonhas Airport in one typical week schedule, according to Diio Mi Tool, and extrapolated for the entire operating year for the report summary perspective.

Chapter IV

Outcomes

Introduction

During this research, it was identified that airport noise does not only include aircraft emissions, but also other sources, such as road traffic. The airport-side residents are exposed to noise levels, which may be higher than the ones produced by aircraft, at least, in terms of equivalent acoustic energy.

Nonetheless, it is reasonable to acknowledge that the noise perception is very subjective and depends on the sensitivity to noise of each person. This is why despite the fact that the global level of aircraft noise energy has recently decreased, the feeling of disturbance, or annoyance, has increased.

The resolution "balanced approach" from ICAO was selected as base for this study to focus on possible actions in airport operations. The land-use and urban development are not only under the airport operator control but also managed by other stakeholders, such as the airlines and ground-handling companies.

The use of the following procedures does not prevail over safety aspects. In line with this philosophy, the pilot always retains full authority not to comply with such a procedure (even when published), if safety margins may be reduced by its application (i.e. in case of emergency). The interested parties should also re-validate this analysis and recommendations before implementation.

Project Assumptions

1) Project Observation Period:

This research was based on the year of 2016, between January and December for data collection and observation, this is the most recent completed full year with most available data.

2) Project Aircraft:

The selected aircraft was the Airbus A320-210 equipped with CFM56-5B4 engines with Honeywell 131-9 APU as "Project Aircraft" to serve as reference for all calculations and recommendations based on the following:

a. Aircraft with larger quantity of movements "to" and "from" CGH per described on Table 2.

Table 2. CGH 2016.

Aircraft Type	Movements	Share
A320 Family	89,429	51,13%
B737 Family	76,828	43,93%
E-190/195 Family	8,638	4,94%
Total	174,895	100,00%

Source. Diio Mi / Innovata Report run on October 2017.

b. Aircraft operated by the majority (3 out 4) of ABEAR airlines, making it easier to access data.

c. The CFM56-5B4 is the most operated engine between A320 operators in Brazil per described in Table 3.

Table 3. Brazil A320's (in service).

Aircraft Type	Aircraft Variant	Engine Variant	Share
A320	210 (CFM)	56-5B4	68%
A320	230 (IAE)	V2527	32%

Source. Ascend Fleet Data Report run on October 2017.

d. The APU model Honeywell 131-9 is the most operated APU between A320 operators in Brazil per described in table 4 below.

Table 4. A320 APU (in service in Brazil).

Aircraft Type	APU Variant	Share
A320	131-9 (Honeywell)	75%
A320	APS 3200 (UTC)	25%

Source. Ascend Fleet Data Report run on October 2017.

e. Regarding different noise level depending on the aircraft, it was verified the certification values per listed on the USA FAA – Advisory Circular 36 1H (24/04/2012) and confirmed that the noise difference between the two most operated aircraft in CGH is irrelevant. Considering the 737-800 in the approach phase produces 96.8 EPNdB, while the A320 produces 95.8 EPNdB in the same flight phase, which further validates the use of the A320 as Project Aircraft.

3) Noise measuring sites:

There is an existing research work done by Scatolini F and Alves CJP in 2016, where 62 and 72 DNL (day-night-level) noise contours were chosen in urban sites compatible with residential use. The results of this study were used for the measurements information.

The DNL metric was formally adopted by the National Civil Aviation Agency (ANAC) according to the Brazilian Civil Aviation Regulation 161 (RBAC 161).

Fifteen sites were monitored for at least 168 hours without interruption or seven consecutive days, selected from 23 pre-selected locations, per Figure 9. Selection was based on residential use on the surroundings and the potential exposure to noise.

Data compilation was based on cross-reference between noise measurements and air traffic control records and results were validated by airport meteorological reports. Preliminary diagnoses were established using the standard NBR-13368. Background noise values were calculated based on the Sound Exposure Level (SEL).

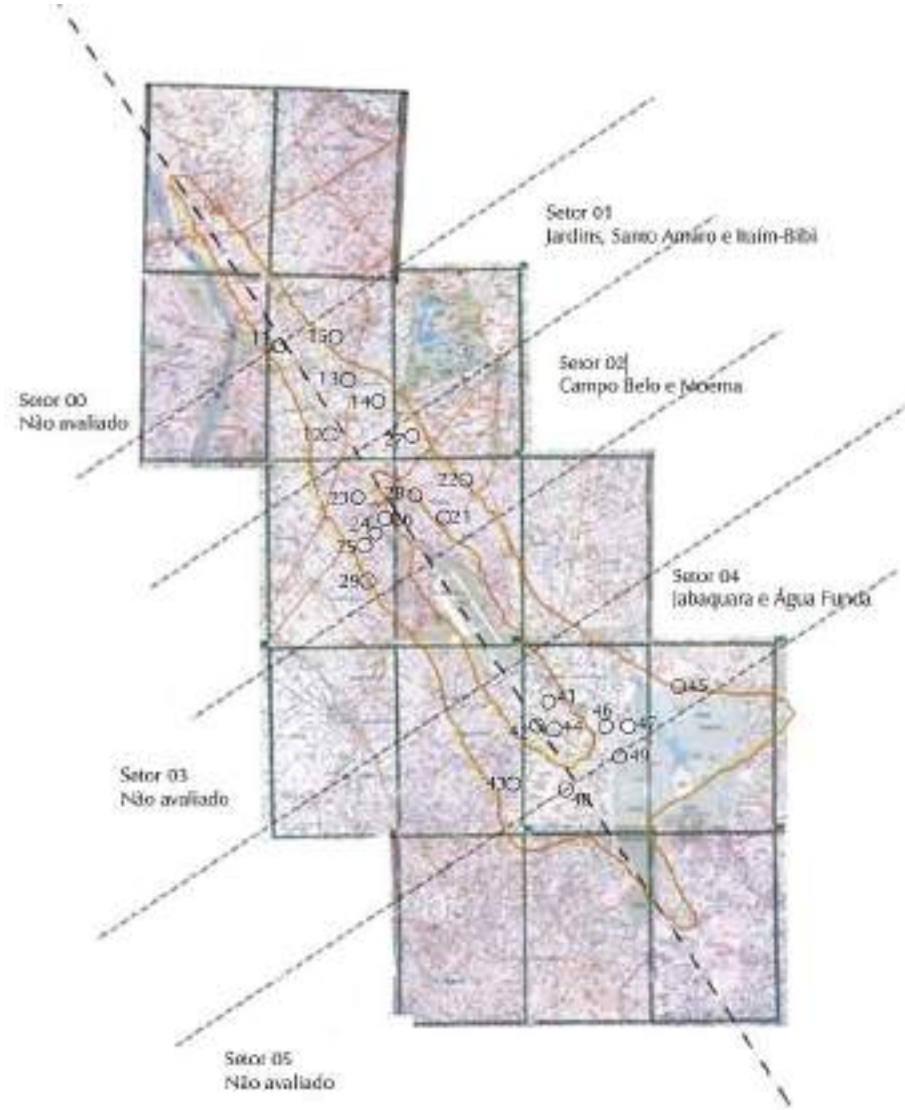

Figure 9. Location of the 23 pre-selected sites.

4) Measurement results

Table 5 summarizes the results for the fifteen sites monitored. With the results shown below the authors were able to verify the impact of the recommended measures this study is triggering looking to position total noise at or below 55 dB level at a given measuring site.

Table 5. Measurement results in fifteen different sites.

Measuring site	No. of hours of the sample	LEq of total noise (dB/hour)	Min LEq – max LEq (dB–hour)	Average of overflights per hour	LEq of background noise (dB/hour)	Average of nominal differences (dB)	Remarks
Sector 01							
11 – Anne Frank Municipal Library	56	61.3	53.8–65.5	14	55.8	5.4	Exclusively residential area. Background noise 1 dB(A) above limit.
13 – São Germano Clinic	56	59.9	53.8–64.1	14	57.3	2.6	Area of mixed use. Total noise in the limit allowed.
12 – EMEF Mary Aux. D´Alquimin Bastos	71	65.3	59.5–67.6	15	58.1	7.2	Site right below the runway axis. Area of mixed use. Moderate to intense traffic.
Sector 02							
23 – EE Napoleão de Carvalho Freire	59	60.6	54.8–64.1	14	56.5	4.1	Exclusively residential area. Background noise 1.5 dB(A) above the limit.
27 – Franciscano Nossa Senhora Aparecida School	58	54.7	42.5–63.7	14	54.7	ZERO	Measured during school winter recess. Area of mixed use. Aircraft noise is blocked by nearby buildings.
25 – Pinheiros Orthopedic Clinic	45	61.4	56.5–64.4	18	56.5	4.8	Area of mixed use. Cobblestones pavement. Moderate to intense traffic.
21 – Brandão Educational Center	118	62.6	53.4–72.9	16	61.8	0.8	Area of mixed use. Relief favorable to reduction of aircraft noise. Background noise 1.8 dB(A) above the limit.
26 – Augusto Laranja School	112	65.5	59.9–70.8	16	62.4	3.1	Exclusively residential area. Site right below the runway axis. Background noise 2.4 dB(A) above the limit.
28 – Ibirapuera University	118	63.8	58.6–69.7	16	62.5	1.3	Area of mixed use with commercial predominance. Intense bus traffic. Background noise 2.5 dB(A) above the limit.
29 – EMEF Chiquinha Rodrigues	113	60.7	52.3–69.1	16	57.0	3.7	Area of mixed use. Cobblestones pavement. Moderate to intense traffic.
Sector 04							
48 – EMEF Armando de Arruda Pereira	64	62.9	58.8–70.8	18	58.7	4.2	Residential area. Relief unfavorable to noise attenuation. Site very sensitive between 19:00 and 21:00, when the heading is inverted. Background noise 3 dB(A) above the limit.
41 – Faculdade Colégio Montessori	70	65.7	53.8–71.1	17	64.8	0.9	Area of mixed use. Bus route. Moderate traffic. Measured during school winter holidays.
44 – Nossa Senhora de Lourdes Hospital	51	61.3	56.7–68.1	17	59.2	2.1	Area of mixed use. Site right below the runway axis. Moderate and disorganized access traffic to the hospital, even on weekends.
45 – Botanical Institute	70	53.7	41.2–63.1	16	ND	0	Aircraft taking off in high altitude. No vehicular traffic. Imperceptible/inaudible aircraft noise.
49 – Nossa Senhora das Graças School	21	67.1	61.6–79.5	17	62.9	4.2	Influence of highway's noise. Small sampling because of the maintenance activity next to the equipment. Background noise 7 dB(A) above the limit.

Source. Scatolini F and Alves CJP, 2016.

5) Selected LDN noise contours

Figure 10 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.

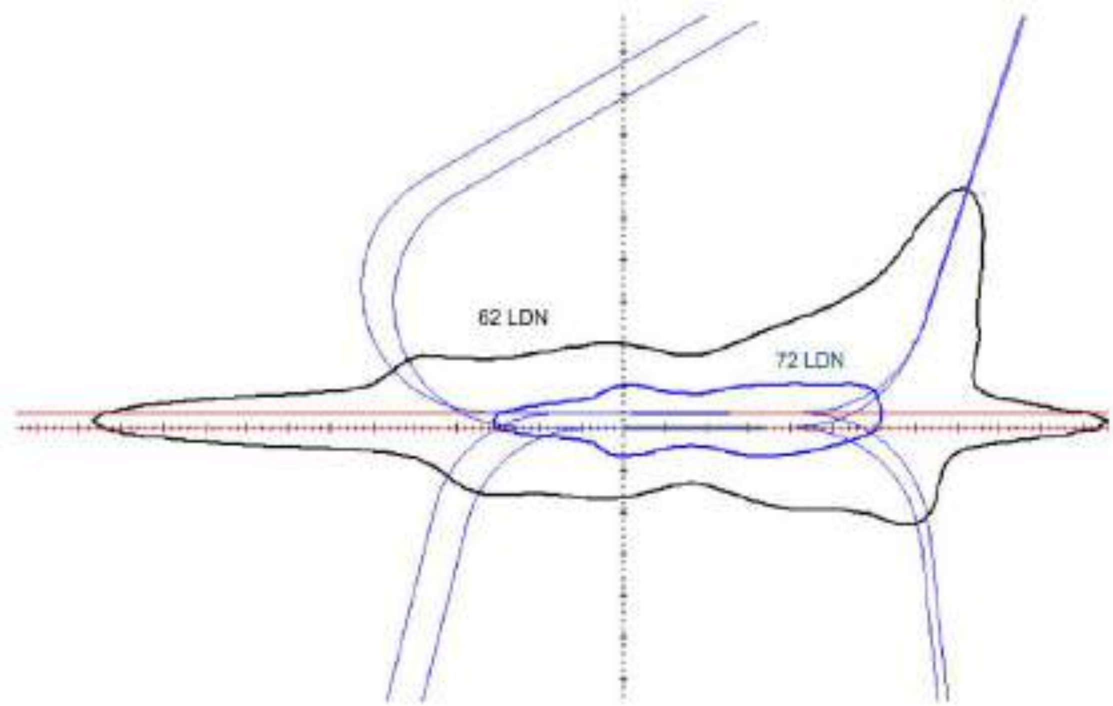

Figure 10. Noise annoyance contours (62 and 72 LDN) for current operation scenario.

These LDN noise contours are used as reference and the noise abatement analysis was performed within this area as required by the Brazilian regulation authority.

6) Carbon Calculation

The combustion of 1 kg of jet fuel in an aircraft engine or APU produces 3.15 kg of carbon dioxide (CO2).

7) Jet-1A fuel density

Jet fuel density conversion from kilograms to liters is 0.803 kg/l or 0.803 g/cm^3.

8) Jet-1A fuel Price

Despite the fuel price differs from each airlines, the authors used an average price over the information from team members and selected R$ 2.5 fuel cost per liter as a reasonable value at this point in time.

9) Diesel fuel Price

Based on Agencia Nacional de Petroleo, the average diesel price in the Sao Paulo State is R$ 3.13.

10) Exchange Rate

Based on the Brazilian Central Bank data, R$3,18 value was selected per every United States Dollar exchange rate, considering it was the average during the first 6 months of 2017.

In-Flight Outcomes

Business Case for Steep Approach

The research defined Noise Abatement Procedures at departure and approach flight phases. During approach, the authors defined the use of a 3.5-degree angle "Steep Approach" on the final approach phase while descending.

In order to produce less noise and, therefore, less fuel burn and other emissions in the final approach phase, the slope angle was increased while in "CDFA - Continuous Descent Final Approach", descending towards the airport from the initial approach "navigation fix" in a gradual, continuous angle with decreased engine thrust level.

The advantages are the improvement of fuel efficiency by reducing the low-altitude level flight time or constant altitude at a lower altitude level, and the reduced noise level by reducing flight time at a higher thrust setting.

Due to the characteristics of Congonhas airport, the proposed procedure is intended to be used only under visual conditions. Its new design requires a slope in the final approach phase of 3.5 degrees. The new procedure is expected to reduce the noise, carbon and fuel consumption as demonstrated below. The analysis compares the current Congonhas approach slope angle of 2.9 degrees and the proposed 3.5 degrees slope angle, initiating the approach at a fix navigation position at 7.7nm distance from runway 17 or 35, depending on which runway is in use per illustrated in Figure 11.

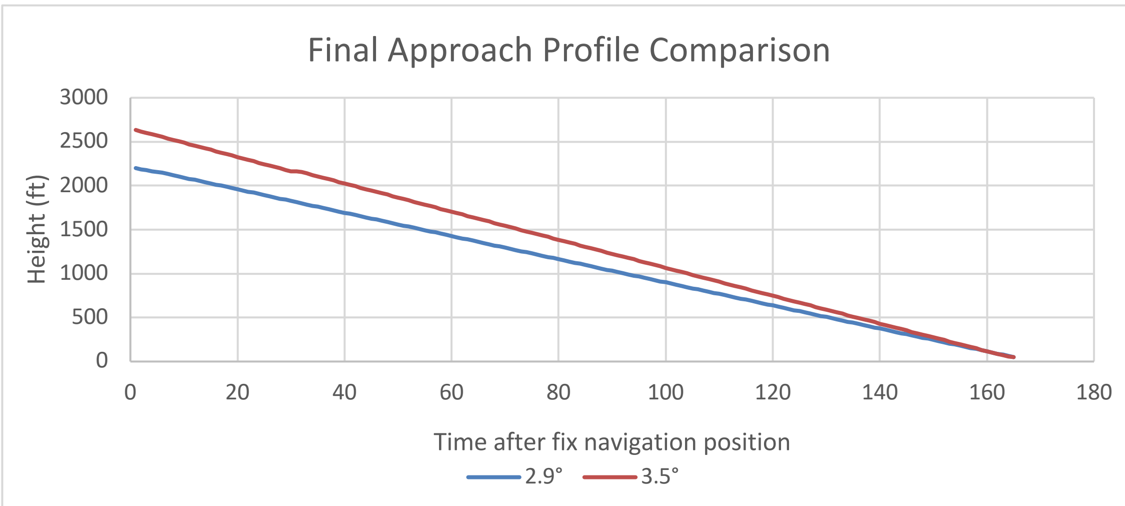

Figure 11. Final Approach Profile Comparison.

The fuel consumption on approaches using the 2.9 degrees slope consumes a total of 96 kg of fuel and when utilizing the 3.5 degrees slope, it consumes a total of 82 kg of fuel. Therefore, the fuel difference between the two proposed slopes is 14 kg, or a 14.4% reduction.

Regarding noise reduction, considering the new approach profile per demonstrated in Table 1 of the Annex section, 164 seconds were accounted with a variation of 3.2 to 3.5 dB (3.3 dB average) reduction per landing with having the observation point at surface and right below the aircraft path.

Given the fuel economy of 14 kilograms, using a conservative approach concerning the different types of aircraft operating at Congonhas airport, the authors considered the fuel savings of 10 kg per landing in the assessment as demonstrated below along with the expected total fuel and carbon saving and noise reduction average per landing.

Table 6. Steep Approach Calculations (1 year operation).

Total Movements	Landings	Fuel Saving (Kg)	Fuel Saving (Liter)	Carbon Saving (CO^2)	Fuel Saving (US$)	Noise Reduction Average per Landing (dB)
174,895	87,447	874,475	1,089,010	2,754,596	856,140	3.3

Additional savings is typically expected with the result of steep approach procedures allowing for less use of the aircraft engines, therefore maintenance cost will be reduced in a given period. However, engine maintenance cost reduction benefit was excluded from the in-flight outcomes calculation considering the NADP1 departures, which is also being proposed and will trigger more engine use.

Business Case for NADP1 Departures

During takeoff, NADP 1 type aimed to reduce noise exposure in the airport vicinity.

This procedure involves a power reduction at or above the prescribed minimum altitude and the delay of flap/slat retraction until the prescribed maximum altitude is attained. At the prescribed maximum altitude, accelerate and retract flaps/slats on schedule while maintaining a positive rate of climb, and complete the transition to normal enroute climb speed.

The noise abatement procedure is not to be initiated at less than 240 m (800 ft) above aerodrome elevation. The initial climbing speed to the noise abatement initiation point shall not be less than V2 + 20 km/h (10 kt).

On reaching an altitude at or above 240 m (800 ft) above aerodrome elevation, adjust and maintain engine power/thrust in accordance with the noise abatement power/thrust schedule provided in the aircraft operating manual. Maintain a climb speed of V2 + 20 to 40 km/h (10 to 20 kt) with flaps and slats in the take-off configuration.

At no more than an altitude equivalent to 900 m (3 000 ft) above aerodrome elevation, while maintaining a positive rate of climb, accelerate and retract flaps/slats on schedule. At 900 m (3 000 ft) above aerodrome elevation, accelerate to en-route climb speed (ICAO DOC 8168).

For noise abatement study, especially regarding wave divergence, this research has taken into account that as there is a two times multiplier of the source-receiver distance, for a determined point source, the sound level reduces 6 dB. (CAETANO, 2016. p. 28)

Based on Table 2 of the Annex section, CAETANO rule was applied to determine the noise level based on how high the aircraft was and its difference when using NADP 1 procedure.

Figure 12 below denotes the rate of noise reduction as the distance between the noise source and the receiver increases.

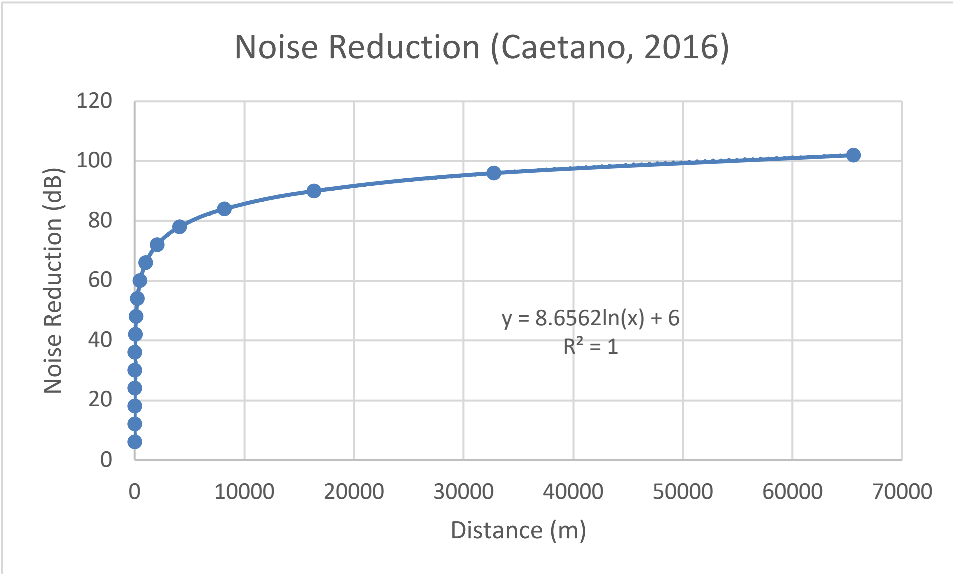

Figure 12. Departure Profile (Current vs. NADP).

Per Figure 13, the departure profile comparison between the current procedure and the new procedure results with using NADP 1. It is clear that the new procedure triggers a higher altitude path profile, earlier in the departure phase, reducing the noise at positions closer to the airport.

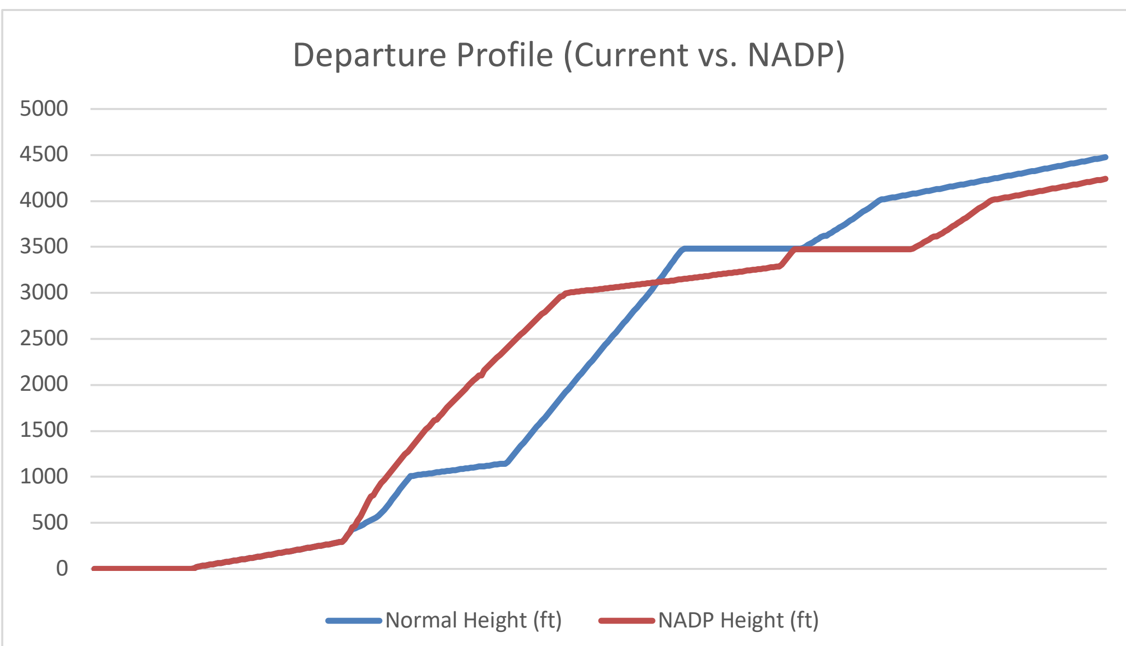

Figure 13. Departure Profile (Current vs. NADP).

Additionally for the noise abatement study, it is important to consider the noise produced by the aircraft on the airport movement areas. For this matter, the Figure 14 illustrate the noise profile for N1 engine thrust on the ground. As in the example, for a TOW of 70,385, the noise produced by the engine thrust is approximately 82,4 dB.

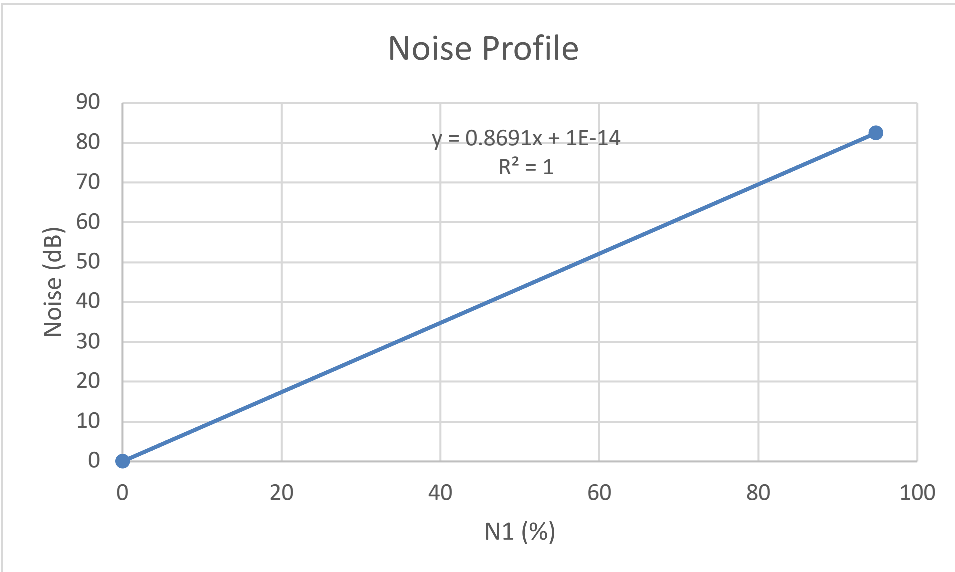

Figure 14. Noise Profile for N1 engine thrust.

Considering both climb procedures require to fly over the fix SP001 with same speed and altitude, the NADP 1 profile has a fuel consumption of 5 kilograms more compared to the normal climb procedure.

Table 7. NADP 1 Departures Calculations.

Total Movements	Departures	Fuel Burn (Kg)	Fuel Burn (Liter)	Carbon Emissions (CO^2)	Fuel Spent (US$)	Noise reduction (dB)
174,895	87,447	(437,235)	(544,502)	(1,377,290)	(428,068)	Up to 6

Business Case for Idle Reverse Thrust

This research also tested the use of "Idle Reverse Thrust" after landing, in dry runway scenario only. Considering different aircraft types, captain discretion due to safety reasons for instance, and wet runway scenarios, the authors have reduced the opportunity size in half (50%) of total landings to be more conservative.

Considering savings of 15 kg per landing per a study conducted at LATAM Airlines in 2017 for idle reverse thrust usage, the savings per year in Congonhas is significant as demonstrated with Table 8.

More impactful than the fuel savings in this case is the noise reduction. Noise generated due to overflying aircraft is momentary and affects the residential colonies located beneath the flight paths. However, the noise produced during application of thrust reverser is much higher laterally and affects the residential areas around the airport.

With the reduction on thrust reverse usage, there is noise mitigation up to 50 dB per landing, based on Airbus AFM – Aircraft Flight Manual, Lateral Noise Levels Reference. That is how much an observer nearby the Congonhas runway would fell in terms of noise reduction when the thrust reverser is not used, and therefore much less annoyed during the entire day, considering several landings.

Table 8. Idle Reverse Thrust Calculations.

Total Movements	**Landings @ 50%**	**Fuel Saving (Kg)**	**Fuel Saving (Liter)**	**Carbon Saving (CO^2)**	**Fuel Saving (U$)**	**Noise reduction (dB)**
174,895	43,723	655,845	816,743	2,065,912	642,094	Up to 50dB

On the Ground Outcomes

Business Case for APU Usage Reduction

One area at the airport where substantial fuel savings can be achieved is with reducing APU usage, which powers the aircraft's electrical systems on the ground, when the aircraft's engines are turned off.

Modern airports are installing fixed electrical ground power units. These plug the aircraft directly into main power sources, so the aircraft does not use fuel while sitting at the airport gate. Every airport is different. Power can be provided either by ground-based generators or via a frequency converter plugged directly into the main power supply of the airport, mandatory use of limited times for APU use when docked.

One other alternative is to rent ground support equipment (GSE) from specialized suppliers. They normally operate with Diesel, at a lower volume if compared to APU fuel usage, but the noise produced is almost the same.

Decreasing the amount of time that the APU is in service cuts APU maintenance costs, as well as fuel usage. Installing these units can result in a substantial reduction in fuel consumption and CO^2 production.

For higher efficiency operation, these ground power units must be combined with air conditioning plug as well, installed on each station.

It is important to mention that for the GSE rented financial analysis, it was not considered the usage of these equipment during two situations:

- Overnight procedures: further research needed to be performed to identify and combine programmed maintenance with ground equipment availability;

- Transits with less than 21 minutes: the APU is recommended for this situation, as it may impact on the airline operation schedule.

For the fixed electrical power provided by the airports, all transits could benefit from it. Even though, overnight procedures were not considered for this study.

Considering these options, two possible outcomes could be verified:

- For fixed electrical power
  - Airport Rate: 80-90 dollars per hour (Brasília's Airport Authority "Inframerica" reference)
  - APU consumption: 165 liters/hour (Airbus manual reference)
  - Jet Fuel Density = 0.803
  - Jet Fuel: R$ 2.5 with dollar 3.18, converting to U$ 0.786
  - APU maintenance costs = U$ 30/hour (Avianca Brasil reference)

Therefore, APU costs per hour is (165 x U$0.786) + U$30 = U$159.69, while fixed electrical power costs U$ 80 per hour. U$ 79.69 of savings per hour.

- Assumptions for total costs savings:
  - 25 min of usage of APU in Turn Around Time (average turnaround time calculated by industry average schedule in Congonhas, using DiioMi Tool multiplied by percentage of using APU on ground after landing according to Airbus. See Table 9.

Table 9. Yearly saving using electric outlets instead of APU calculation.

Itens	**25 minutes usage of outlet instead of APU**
APU fuel consumption (l)	68.75
APU consumption (kg)	55.21
Total Saving per movement	**U$ 33.20**
Total turn-around movements (2016)	87,447
Savings per year	**U$ 2,903,240**
CO^2 reduction per year	**15,208,039**

Results above was clearly indicators that this usage will benefit airlines.

When it comes to Congonhas airport administration, herein below you can find the investment opportunity:

- Capex Investment by Parking Position: U$400.000 (Inframerica, 2017)
- Yearly Operation Costs: U$216.000
- 25 minute Estimated Revenue: U$33,33
- Revenue Improvement per Year: 3 percent
- Weighted Average Cost of Capital: 7,5% year

Using this assumptions, a NPV Formula was applied in this study (Militaru, 2017):

$$NPV = PV_B - PV_C \Leftrightarrow$$

$$\Leftrightarrow NPV = \left[\frac{B_1}{(1+r)^{t+1}} + \ldots + \frac{B_T}{(1+r)^T}\right] - \left[\frac{C_1}{(1+r)^1} + \ldots + \frac{C_t}{(1+r)^t}\right].$$

Table 10. Cashflow for Airport Investment.

Year	CashFlown	
0	U$	-9.600.000,00
1	U$	2.628.000,00
2	U$	2.785.680,00
3	U$	2.864.520,00
4	U$	2.943.360,00
5	U$	3.022.200,00
NPV	**U$**	**1.739.670,32**

In a five-year period, the NPV is higher than 0, indicating that this investment is viable.

- For GSE rental:
  - GPU consumption: 15 liters/hour
  - ASU consumption: 12 liters/hour
  - GPU + ASU Maintenance: U$ 30/hour (Avianca Brasil reference)
  - Diesel price: R$3,132, with dollar at 3.18, converting at U$0.985.

Therefore, GPU+ASU costs per hour is (15+12) x 0,985 + 30 = U$59.6.

It was calculated fuel cost reduction in both scenarios, considering the previous APU costs:

Table 11. Yearly saving using GPU instead of APU calculation.

Itens	**25 minutes usage of GPU instead of APU**
APU Liter consumption	43.86
APU Maintenance	12.5
Total Cost per movement	**U$ 56.36**
GPU + ACU Costs	U$ 24.83
Total Saving per movement	**U$ 31.53**

According to calculations, an airline company which uses a GPU instead of the APU, will save U$31.53 per movement. At a 237 average daily flights, this saving could reach U$2.7 Million.

APU Noise Reduction

Most civil aircraft utilize an APU that typically uses compressed air to start the engine and power the air conditioning system while on ground as well as to provide electrical power to the aircraft during in-flight and on ground phases . The APU is essentially a gas turbine engine (GTE) consisting of a compression portion, a turbine part and an accessory drive part.

The APU is usually placed inside of a section in the tail end of the aircraft and it is entirely isolated by a titanium shroud that is both fire and sound proof. Noise due to aircraft APUs is one of the most significant sources of noise at airport areas, which is extremely relevant in densely populated cities. Its effects can cause discomfort for people such as those in the airport's vicinity as well as, especially, for aircraft maintenance staff (Kwan and Yang, 1992).

According to a 2005 study conducted by Tam Linhas Aéreas, Pastouchenko, Mendoza, and Brown, noise originated from aircraft's APUs is a significant factor that adds to the overall magnitude of an aircraft ramp noise. Typically, individual airports and international governing bodies standardize and control ramp noise. A major part of the aircraft noise is due to APUs fuel combustion noise (Tam, Pastouchenko, Mendoza, and Brown, 2005).

The study examined the spectral shape of combustion noise in APUs noise, and found that it remained the same even with changes in levels of power, engine size and directivity. It also found that it was the same as the noise produced by the open flame combustion. The combustion noise peak frequency for APUs typically lies between 250 and 350 Hz (Tam, Pastouchenko, Mendoza, and Brown, 2005).

A 2012 study by Shinohara, Iwasawa and Yamada documented the change in noise index used for determining airport noise from WECPNL to Lden in Japan, effective onwards from April 2013 (Shinohara, Iwasawa and Yamada, 2012). Also, it was concluded that aircraft noise was to be limited to within airport premises wherever necessary. Of the aircraft noise factors while it was on ground, noise due to APU operation prior to takeoff, during overnight maintenance or after landing was found to be one of the most significant ones (Shinohara, Iwasawa and Yamada, 2012).

A 2012 Noise Assessment Technical Report for the C130 aircraft by the Defence Infrastructure Organization of the United Kingdom (UK) found that average measured community noise levels from the C130 from four difference locations around the aircraft. It was observed that noise levels increased along with the aircraft's APU power settings (AMEC Environment & Infrastructure UK Limited, 2012). This can be seen from the following figure 15:

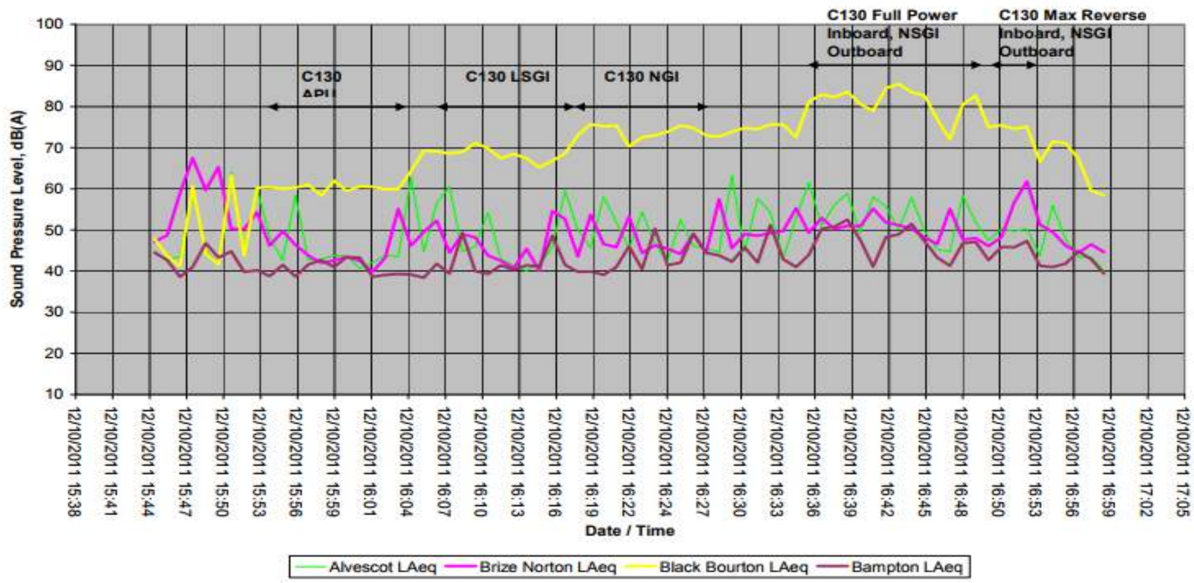

Figure 15. Measurements during APU running showed a 20 dB drop in noise level when a Ground Power Unit (GPU) (AMEC Environment & Infrastructure UK Limited, 2012).

This study concludes that not using the APU of aircraft while grounded can help reduce aircraft noise levels. Aircraft noise due to APUs is one of the most significant contributors to aircraft noise, the main cause of which is the combustion that takes place to power to gas turbine engine used to power the aircraft on the ground as well as during flight.

Business Case for Brake cooling fans (A320 only)

The brake cooling fan does not bring any saving in terms of fuel and monetary, however it brings a lot of silence when switched to off. The system is design to reduce the ground turnaround time, nevertheless it could be better used during the TAT at the airport. The action is to propose the standard operational procedure setting some limitations to use this system at Congonhas airport.

The procedure is to set five minutes of using after parking procedures and turn it back five minutes prior the EOBT. For any technical reason, like maintenance requirement, the procedure should not be follow.

Brake Fans, in case of the Airbus aircraft, are located in the main gear hubs of the aircraft. The brake fans show a HOT sign in amber color when brake temperature exceeds three hundred degrees Celsius. It is necessary to cool the brakes down to below 300° C prior to takeoff and the brake fans should not be used to cool the brakes down to below 250° C (Parks, 2017). The noise levels around the Airbus A380 brake cooling fan systems typically amount to 70 dB(A) (LTG Solutions for Aviation, 2016).

For the Airbus aircraft, the matter is much simpler, as the company itself has recommended not to use the brake fans to cool the brakes below 250° C and, therefore, its usage, in normal conditions, can be widely disengaged throughout all the airline companies.

Chapter V

Conclusions and Recommendations

Conclusions

The predicted results from the researches and from the tests generated by Airbus PEP triggered recommendations combining in-flight and on the ground measures, which shall produce total consolidated reduction of 18,650,223 of CO^2 and U$ 3,973,406 in a 1-year term in comparison to the status-quo. In addition to dollar saving with the reduced fuel burn and different practices, noise and carbon emissions reduction were also achieved per Table 12.

Table 12. Total of savings per activity type (phase of flight).

Activity Type	Business Case	Fuel Saving (L)	Total Saving (U$)	Noise Reduction (dB)	Carbon Reduction (CO^2)
In-Flight	Steep Approach	1,089,010	856,140	3.3 dB per Landing	2,754,596
	NADP 1 Departure	(544,502)	(428,068)	Up to 6 dB per Departure	(1,377,290)
	Idle Reverse Thrust	816,743	642,094	Up to 50 dB per Landing	2,065,912
On the ground	APU Usage Reduction with Electric Power	6,011,981	2,903,240 (considering other costs)	Up to 20 dB per TAT (Turn-around-time)	15,207,005
	Brake Cooling Fan	N/A	N/A	Up to 50 dB per TAT (Turn-around-time)	N/A
TOTAL		**7,373,232**	**U$3,973,406**	**N/A**	**18,650,223**

Airlines in Brazil are looking for cost reduction solutions. If airlines can combine projects that would be beneficial to all stakeholders involved (nearby community, employees, others), their receptivity for new ideas would be even greater.

The proposed solutions provided by this study for air and ground operations demand minor efforts in terms of procedural changes, as well as, low investment from the airlines. Depending on the alternative, the recommendations could impact government investment, which has also proved to be an important source for investments related to this project.

To be able to implement the alternatives, Brazilian airlines should have to agree on some common terms. These concepts would be addressed by ABEAR and conducted as a group-combined project. There could be a single plan, developed by all parties. Best practices and difficulties could be treated by the operational committees.

The research was created in a way that it could be applied to other airports that may need improvements regarding fuel consumption and noise emission reduction.

Carbon emissions were another latent concern. For the next couple of years, according to the climate change deal proposed by the United Nations for Aviation industry, airlines will have to compensate carbon emissions by buying credits that will finance ecological initiatives. With this study, carbon emissions shall be reduced. Such results would directly affect the amount of carbon credits purchases.

Recommendations

This project focused on recommendations that could reduce noise and carbon emission at one specific facility in Brazil, the Congonhas Airport. Considering that airlines in the region are struggling financially in recent times, the suggestions below were developed to achieve these results and save cost, at the same time.

- Noise Abatement Procedures at departure, approach and landing flight phases.
    - During takeoff, NADP 1 procedure type aimed to reduce noise exposure in the airport vicinity.
    - During approach, the recommendation is for the use of 3.5-degree angle “Steep Approach” on final approach phase while descending.
    - After touchdown the use of idle reverse trust, in dry operation environment will sharply reduce the noise exposure in the airport vicinity.
- Fuel saving by APU usage reduction on the ground activities.
    - The Airport should install fixed electrical ground power units around the airport gate, so the aircraft does not use fuel while the engines are off; Air conditioning unit should also be installed.
    - Industry suppliers to provide ground combo equipment including GPU and ASU.

In addition to the above, the authors have researched other best practices for fuel burn reduction, which ultimately translates into noise reduction as well and have listed main topics below for the appreciation of the airlines for further review and evaluation.

- Policy fuel rationalization;
- Reduction in contingency fuel;
- Taxi fuel optimization;
- Single engine taxi-out and increased use of single engine taxi-in;
- Reduction in “Captain” extra fuel;

- Reduction in aircraft empty weight;
- Alternate selection;
- Take-off with optimized flap settings;
- Improved ZFW calculation;
- None use of thrust reverse on landing – long runways;
- Reduced flap landings (for Congonhas airport the IAC 1013 should be respected)

For the implementation phase, it is important that this study is validated by all parties involved, allowing an open discussion and further detailing of the best path forward, with the preparation of an action plan for the implementation of the proposed solutions.

Further Analysis

A more detailed description of the noise abatement procedures will be necessary as a follow on to the recommendations above. Today efficient methods of moving an aircraft around an airport as the new electric tugs. Trials are taking place with semi-automated systems to allow the pilot to access robot tugs. Developing this into a global solution is complex as airport operations differ widely in size and scope. Aircraft manufacturers are even looking at small electrical motors to drive the nose wheels forward, allowing aircraft to taxi using these and switch on their engines once they reach the runway at the busiest airports, leading to a greener environment. This type of tug it is still hard to operate due to its high investments costs, leading to a further analysis theme.

For APU and brake cooling fan noise reduction the authors recommend a deep analysis with several flights in order to see if the mitigation proposed reduces a reasonable quantity of noise on ground.

Nevertheless from the social perspective, further interaction with the AMEA, the Congonhas Residents Association, is necessary in order to better understand their claims and to work together for implementing the noise abatement procedures. Another point of discussion with the Association is how to reduce the airport time curfew so that airlines can operate a bit longer. For instance, a 30 minutes increase in the morning and another 30 minutes in the evening can be very valuable to the airlines, which may be willing to invest in the airport based on the recommendations here above as return to the Association approval on the airport curfew relaxation in exchange to the expected noise and carbon reduction.

Lessons Learned

This capstone project presented an opportunity to the group to learn from experience of putting the lessons from the course in to practice.

The topic selection took a substantial time to start the project and to ensure the desired inputs and outcomes.

Initially, the authors had the broadest idea of outcomes, which would take much longer than the authors had for the project's completion, and therefore had to reduce the scope of work. What in the end leaves open possibilities for other projects to be completed in a common end.

Selected competencies, teamwork and collaboration was substantial for the success of the project. The work in a diverse group for a complex developed topic was a bit complicated, design project proposals sometimes took a different direction and the authors had to manage the scope.

Communication is the most important skill among teams for problem solving and conflict negotiation.

The excellent work of facilitators enabled the engagement and success of the proposed work, mainly in the organization and the time management keeping everyone on the same page.

A factor of difficulty that the authors found was always the time management, and when duties were to be finalized at the last minute the authors had substantial unforeseen events, such as the development of noise reduction study tables, when the authors were to run the study, one of the software was not with the appropriate module and the authors had to look at another solution in another airline company to solve the problem.

The total savings expected were also short when comparing to the group expectation.

INTENTIONALLY LEFT BLANK

References

A theoretical framework for environmental noise annoyance. Stallen, P.J., 1999. Noise & Health 1 (3), 69–79

ABEAR Panorama 2016. Retrieve from http://abear.com.br/uploads/arquivos/dados_e _fatos_arquivos_ptbr/Panorama_2016.pdf

Air pollution and hospital admissions for cardiovascular disease in Tuscon. Schwartz, J., 1997. Epidemiology 8, 371e377

Aircraft noise-abatement and mitigation strategies Raquel Girvin.(2009). Retrieve from Journal of Air Transport Management Elsevier

Airline Cost Management Group (ACMG) Enhanced Report - Sept. 2015. Shell Global Prices http://www.shell.com/business-customers/aviation/ppp/our-posted-airfield-prices.html

Airport related emissions and impacts on air quality: application to the Atlanta International Airport. Unal, A., Hu, Y., Chang, M.E., Odman, M.T., Russell, A.G., 2005. Atmos. Environ. 39, 5787e5798

Background noise analysis in urban airport surroundings of Brazilian cities, Congonhas Airport, São Paulo - Fabio Scatolini, Cláudio Jorge Pinto Alves. Revista Saúde Pública 2016 - http://www.rsp.fsp.usp.br/

Barulho ensurdecedor tira o sono dos vizinhos do Aeroporto de Congonhas. Retrieve from http://g1.globo.com/sao-paulo/sptv-2edicao/videos/t/edicoes/v/barulho-ensurdecedor-tira-o-sono-dos-vizinhos-do-aeroporto-de-congonhas/6029568/

Boeing Database, (2016). Retrieved from http://www.boeing.com/commercial/noise/ list.page

Challenging the contours: critical cartography, local knowledge and the public. Cidell, J., 2008. Environment and Planning A 40 (5), 1202–1218

Concentrations, sources and geochemistry of airborne particulate matter at a major European airport. J. Environ. Monit. 12, 854e862

Contemporary measures for noise reduction in airport surroundings by Fedja Netjasov.(2012)

Continuous Descent Operations (CDO) Manual - ICAO Doc 9931

Easing the concept ‘‘Balanced Approach’’ to airports with densely busy surroundings – The case of Congonhas Airport - Aeronautics Institute of Technology (ITA)/Civil Engineering Division, Brazil - Fabio Scatolini, Cláudio Jorge Pinto Alves, Rogéria de Arantes Gomes Eller. Applied Acoustics 105 (2016) 75–82

Environmental capacity and airport operations: current issues and future prospects. Upham, P., Thomas, C., Gillingwater, D., Raper, D., 2003. Journal of Air Transport Management 9 (3), 15–145

Environmental capacity and European air transport: stakeholder opinion and implications for modeling. Upham, P., Raper, D., Thomas, C., McLellan, M., Lever, M., Lieuwen, A., 2004. Journal of Air Transport Management 10 (3), 199– 205

Environmental Protection / Aircraft Noise - ICAO Annex 16, Volume 1

Environmental Report 2016 ICAO. Retrieved from https://www.icao.int/environmental protection/Documents/ICAO%20Environmental%20Report%202016.pdf

European Commission - Science for Environment Policy, Noise abatement approaches - April 2017, Issue 17

Getting to Grips with Aircraft Noise, Flight Operations Support & Line Assistance AIRBUS

Global Market Forecast 2015–2034 Airbus, (2014). Retrieved from www.airbus.com/ company/market/forecast/

Guidance on Environmental Assessment of Proposed Air Traffic Management Operational Changes - ICAO Doc 10031

Guidance on the Balanced Approach to Aircraft Noise Management. Second edition - ICAO Doc 9829

Health effects of particulate air pollution e a review of epidemiological evidence. Rückerl, R., Schneider, A., Breitner, S., Cyrys, J., Peters, A., 2011. Inhal. Toxicol 23, 555e592.

Ninth Meeting - Report of the Committee on Aviation Environmental Protection. (2013) (Doc 10012, CAEP/9)

Noise Abatement Procedures: Review of Research, Development and Implementation Projects - Discussion of Survey Results - ICAO Doc 9888

Noise within the social context: annoyance reduction through fair procedures. Maris, E., Stallen, P.J., Vermund, R., Steensma, H., 2007. Journal of the Acoustic Society of America 121 (4), 2000–2010.

Personal and social variables as co-determinants of noise annoyance. Guski, R., 1999. Noise Health 1 (3), 45–56

Presentation on The Balanced Approach to Aircraft Noise Management ICAO. Retrieve from https://www.icao.int/environmentalprotection/Documents/Publications/Guidance_BalancedApproach_Noise.pdf

Procedures for Air Navigation Services – Aircraft Operations (PANS-OPS) - ICAO Doc 8168 Volume 1

Property-Value Impacts of an Environmental Disamenity: The Case of Landfills, Journal of Real Estate Finance and Economics, 2001, 22:2/3, 185–202. Hite, D., W. Chern, F. Hitzhusen and A. Randall

Psychological stress and the coping process. McGraw-Hill, New York. Lazarus, R.S., 1966.

Recommended Method for Computing Noise Contours Around Airports - ICAO Doc 9911

Review of Noise Abatement Procedure Research & Development and Implementation Results. ICAO (2007). Retrieved from: https://www.icao.int/environmental-protection/Documents/ReviewNADRD.pdf

The Impact of Airport Noise on Residential Real Estate. Bell, R. (2001). The Appraisal Journal, July, 312-321

Utility of net present value (NPV) for firms in today's economy. Militaru, I. (2016). Romanian Economic and Business Review, 12/2016, Volume 11, Issue 4.

INTENTIONALLY LEFT BLANK

Appendix

Tables

1) *Steep Approach Noise Comparison*

2) *Departure Noise Comparison*

Table 1. Steep Approach Noise Comparison

Slope	2.9°			3.5°			Noise Difference (dB)
Time (s)	N1 (%)	Height (ft)	Noise (dB)	N1 (%)	Height (ft)	Noise (dB)	
1.0	53,13	2200	46,2	49,46	2634	43,0	-3,2
2.0	53,12	2187	46,2	49,44	2618	43,0	-3,2
3.0	53,11	2174	46,2	49,43	2602	43,0	-3,2
3.8	53,1	2163	46,1	49,42	2585	43,0	-3,2
4.1	53,15	2159	46,2	49,4	2569	42,9	-3,3
5.1	53,09	2146	46,1	49,39	2553	42,9	-3,2
6.1	53,08	2133	46,1	49,38	2537	42,9	-3,2
7.1	53,06	2119	46,1	49,37	2520	42,9	-3,2
8.1	53,06	2106	46,1	49,35	2504	42,9	-3,2
9.1	53,04	2092	46,1	49,34	2488	42,9	-3,2
10.1	53,03	2079	46,1	49,33	2472	42,9	-3,2
11.1	53,02	2066	46,1	49,32	2456	42,9	-3,2
12.1	53,01	2052	46,1	49,3	2439	42,8	-3,2
13.1	53	2039	46,1	49,29	2423	42,8	-3,2
14.1	52,99	2026	46,1	49,28	2407	42,8	-3,2
15.1	52,98	2012	46,0	49,26	2391	42,8	-3,2
16.1	52,97	1999	46,0	49,25	2374	42,8	-3,2
17.1	52,96	1986	46,0	49,24	2358	42,8	-3,2

18.1	52,95	1972	46,0	49,23	2342	42,8	-3,2
19.1	52,94	1959	46,0	49,21	2326	42,8	-3,2
20.1	52,93	1945	46,0	49,2	2310	42,8	-3,2
21.1	52,92	1932	46,0	49,19	2294	42,8	-3,2
22.1	52,91	1919	46,0	49,18	2277	42,7	-3,2
23.1	52,9	1905	46,0	49,16	2261	42,7	-3,3
24.1	52,89	1892	46,0	49,15	2245	42,7	-3,3
25.1	52,88	1879	46,0	49,14	2229	42,7	-3,3
26.1	52,87	1865	45,9	49,13	2213	42,7	-3,3
27.1	52,85	1852	45,9	49,11	2196	42,7	-3,3
28.1	52,84	1839	45,9	49,1	2180	42,7	-3,3
29.1	52,83	1825	45,9	49,09	2164	42,7	-3,3
30.1	52,82	1812	45,9	49,08	2160	42,7	-3,3
31.1	52,81	1799	45,9	49,15	2155	42,7	-3,2
32.1	52,8	1786	45,9	49,07	2139	42,6	-3,2
33.1	52,79	1772	45,9	49,06	2122	42,6	-3,2
34.1	52,78	1759	45,9	49,04	2106	42,6	-3,3
35.1	52,77	1746	45,9	49,03	2090	42,6	-3,3
36.1	52,76	1732	45,9	49,02	2074	42,6	-3,3
37.1	52,75	1719	45,8	49,01	2058	42,6	-3,3
38.1	52,74	1706	45,8	48,99	2042	42,6	-3,3
39.1	52,73	1692	45,8	48,98	2026	42,6	-3,3
40.1	52,72	1679	45,8	48,97	2009	42,6	-3,3

41.1	52,71	1666	45,8	48,96	1993	42,6	-3,3
42.1	52,7	1652	45,8	48,94	1977	42,5	-3,3
43.1	52,69	1639	45,8	48,93	1961	42,5	-3,3
44.1	52,68	1626	45,8	48,92	1945	42,5	-3,3
45.1	52,67	1613	45,8	48,91	1929	42,5	-3,3
46.1	52,66	1599	45,8	48,89	1913	42,5	-3,3
47.1	52,65	1586	45,8	48,88	1897	42,5	-3,3
48.1	52,64	1573	45,7	48,87	1881	42,5	-3,3
49.1	52,63	1560	45,7	48,86	1865	42,5	-3,3
50.1	52,62	1546	45,7	48,85	1849	42,5	-3,3
51.1	52,61	1533	45,7	48,83	1832	42,4	-3,3
52.1	52,6	1520	45,7	48,82	1816	42,4	-3,3
53.1	52,59	1506	45,7	48,81	1800	42,4	-3,3
54.1	52,58	1493	45,7	48,8	1784	42,4	-3,3
55.1	52,57	1480	45,7	48,78	1768	42,4	-3,3
56.1	52,56	1467	45,7	48,77	1752	42,4	-3,3
57.1	52,55	1453	45,7	48,76	1736	42,4	-3,3
58.1	52,53	1440	45,7	48,75	1720	42,4	-3,3
59.1	52,53	1427	45,7	48,74	1704	42,4	-3,3
60.1	52,51	1414	45,6	48,72	1688	42,3	-3,3
61.1	52,51	1400	45,6	48,71	1672	42,3	-3,3
62.1	52,49	1387	45,6	48,7	1656	42,3	-3,3
63.1	52,49	1374	45,6	48,69	1640	42,3	-3,3

64.1	52,47	1361	45,6	48,67	1624	42,3	-3,3
65.1	52,47	1347	45,6	48,66	1608	42,3	-3,3
66.1	52,46	1334	45,6	48,65	1592	42,3	-3,3
67.1	52,44	1321	45,6	48,64	1576	42,3	-3,3
68.1	52,43	1308	45,6	48,63	1560	42,3	-3,3
69.1	52,42	1295	45,6	48,61	1544	42,2	-3,3
70.1	52,41	1281	45,5	48,6	1528	42,2	-3,3
71.1	52,4	1268	45,5	48,59	1512	42,2	-3,3
72.1	52,39	1255	45,5	48,58	1496	42,2	-3,3
73.1	52,38	1242	45,5	48,57	1480	42,2	-3,3
74.1	52,37	1228	45,5	48,55	1464	42,2	-3,3
75.1	52,36	1215	45,5	48,54	1448	42,2	-3,3
76.1	52,35	1202	45,5	48,53	1432	42,2	-3,3
77.1	52,34	1189	45,5	48,52	1416	42,2	-3,3
78.1	52,33	1176	45,5	48,51	1400	42,2	-3,3
79.1	52,32	1162	45,5	48,49	1384	42,1	-3,3
80.1	52,31	1149	45,5	48,48	1368	42,1	-3,3
81.1	52,3	1136	45,5	48,47	1352	42,1	-3,3
82.1	52,29	1123	45,4	48,46	1336	42,1	-3,3
83.1	52,28	1110	45,4	48,45	1320	42,1	-3,3
84.1	52,27	1096	45,4	48,43	1304	42,1	-3,3
85.1	52,26	1083	45,4	48,42	1288	42,1	-3,3
86.1	52,25	1070	45,4	48,41	1272	42,1	-3,3

87.1	52,24	1057	45,4	48,4	1256	42,1	-3,3
88.1	52,24	1044	45,4	48,39	1240	42,1	-3,3
89.1	52,22	1031	45,4	48,38	1224	42,0	-3,3
90.1	52,22	1017	45,4	48,36	1208	42,0	-3,4
91.1	52,21	1004	45,4	48,35	1192	42,0	-3,4
92.1	52,19	991	45,4	48,34	1176	42,0	-3,3
93.1	52,19	978	45,4	48,33	1161	42,0	-3,4
94.1	52,17	965	45,3	48,32	1145	42,0	-3,3
95.1	52,17	952	45,3	48,3	1129	42,0	-3,4
96.1	52,16	938	45,3	48,29	1113	42,0	-3,4
97.1	52,15	925	45,3	48,28	1097	42,0	-3,4
98.1	52,14	912	45,3	48,27	1081	42,0	-3,4
99.1	52,13	899	45,3	48,26	1065	41,9	-3,4
100.1	52,12	886	45,3	48,24	1049	41,9	-3,4
101.1	52,11	873	45,3	48,23	1033	41,9	-3,4
102.1	52,1	860	45,3	48,22	1017	41,9	-3,4
103.1	52,09	846	45,3	48,21	1001	41,9	-3,4
104.1	52,08	833	45,3	48,2	986	41,9	-3,4
105.1	52,07	820	45,3	48,19	970	41,9	-3,4
106.1	52,06	807	45,2	48,17	954	41,9	-3,4
107.1	52,05	794	45,2	48,16	938	41,9	-3,4
108.1	52,04	781	45,2	48,15	922	41,8	-3,4
109.1	52,03	768	45,2	48,14	906	41,8	-3,4

110.1	52,02	755	45,2	48,13	890	41,8	-3,4
111.1	52,01	741	45,2	48,12	875	41,8	-3,4
112.1	52	728	45,2	48,11	859	41,8	-3,4
113.1	51,99	715	45,2	48,09	843	41,8	-3,4
114.1	51,98	702	45,2	48,08	827	41,8	-3,4
115.1	51,97	689	45,2	48,07	811	41,8	-3,4
116.1	51,96	676	45,2	48,06	795	41,8	-3,4
117.1	51,95	663	45,1	48,05	779	41,8	-3,4
118.1	51,94	650	45,1	48,04	764	41,8	-3,4
119.1	51,93	637	45,1	48,03	748	41,7	-3,4
120.1	51,92	623	45,1	48,01	732	41,7	-3,4
121.1	51,91	610	45,1	48	716	41,7	-3,4
122.1	51,9	597	45,1	47,99	700	41,7	-3,4
123.1	51,89	584	45,1	47,98	685	41,7	-3,4
124.1	51,88	571	45,1	47,97	669	41,7	-3,4
125.1	51,87	558	45,1	47,96	653	41,7	-3,4
126.1	51,86	545	45,1	47,94	637	41,7	-3,4
127.1	51,85	532	45,1	47,93	621	41,7	-3,4
128.1	51,85	519	45,1	47,92	605	41,6	-3,4
129.1	51,83	506	45,0	47,91	590	41,6	-3,4
130.1	51,83	493	45,0	47,9	574	41,6	-3,4
131.1	51,82	480	45,0	47,89	558	41,6	-3,4
132.1	51,81	466	45,0	47,88	542	41,6	-3,4

133.1	51,8	453	45,0	47,86	527	41,6	-3,4
134.1	51,79	440	45,0	47,85	511	41,6	-3,4
135.1	51,78	427	45,0	47,84	495	41,6	-3,4
136.1	51,77	414	45,0	47,83	479	41,6	-3,4
137.1	51,76	401	45,0	47,82	463	41,6	-3,4
138.1	51,75	388	45,0	47,81	448	41,6	-3,4
139.1	51,74	375	45,0	47,8	432	41,5	-3,4
140.1	51,73	362	45,0	47,78	416	41,5	-3,4
141.1	51,72	349	44,9	47,77	400	41,5	-3,4
142.1	51,71	336	44,9	47,76	385	41,5	-3,4
143.1	51,7	323	44,9	47,75	369	41,5	-3,4
144.1	51,69	310	44,9	47,74	353	41,5	-3,4
145.1	51,68	297	44,9	47,73	337	41,5	-3,4
146.1	51,67	284	44,9	47,72	322	41,5	-3,4
147.1	51,66	271	44,9	47,71	306	41,5	-3,4
148.1	51,65	258	44,9	47,69	290	41,4	-3,4
149.1	51,65	245	44,9	47,68	275	41,4	-3,5
150.1	51,64	232	44,9	47,67	259	41,4	-3,5
151.1	51,63	219	44,9	47,66	243	41,4	-3,5
152.1	51,62	206	44,9	47,65	227	41,4	-3,5
153.1	51,61	193	44,9	47,64	212	41,4	-3,5
154.1	51,6	180	44,8	47,63	196	41,4	-3,5
155.1	51,59	167	44,8	47,62	180	41,4	-3,5

156.1	51,58	154	44,8	47,6	165	41,4	-3,5
157.1	51,57	141	44,8	47,59	149	41,4	-3,5
158.1	51,56	128	44,8	47,58	133	41,4	-3,5
159.1	51,55	115	44,8	47,57	118	41,3	-3,5
160.1	51,54	102	44,8	47,56	102	41,3	-3,5
161.1	51,53	89	44,8	47,55	86	41,3	-3,5
162.1	51,51	76	44,8	47,51	70	41,3	-3,5
163.1	51,44	63	44,7	47,43	55	41,2	-3,5
164.0	51,4	50	44,7	47,4	50	41,2	-3,5

Table 2. Departure Noise Comparison

Current Time (s)	NADP Time (s)	Current N1 (%)	NADP N1 (%)	Current Height (ft)	NADP Height (ft)	Current Noise (dB)	NADP Noise (dB)	Current Noise Reduction (dB)	NADP Noise Reduction (dB)	Delta Noise Reduction (dB)	Current Noise Level (dB)	NADP Noise Level (dB)
0	0	31,03	31,03	0	0	26,968173	26,968173	0	0	0	26,968173	26,968173
1	1	35,43	35,43	0	0	30,792213	30,792213	0	0	0	30,792213	30,792213
2	2	48,5	48,5	0	0	42,15135	42,15135	0	0	0	42,15135	42,15135
3	3	64,36	64,36	0	0	55,935276	55,935276	0	0	0	55,935276	55,935276
4	4	80,22	80,22	0	0	69,719202	69,719202	0	0	0	69,719202	69,719202
5	5	94,17	94,17	0	0	81,843147	81,843147	0	0	0	81,843147	81,843147
6	6	94,17	94,17	0	0	81,843147	81,843147	0	0	0	81,843147	81,843147
7	7	93,44	93,44	0	0	81,208704	81,208704	0	0	0	81,208704	81,208704
8	8	93,45	93,45	0	0	81,217395	81,217395	0	0	0	81,217395	81,217395
9	9	93,62	93,62	0	0	81,365142	81,365142	0	0	0	81,365142	81,365142
10	10	93,8	93,8	0	0	81,52158	81,52158	0	0	0	81,52158	81,52158
11	11	93,98	93,98	0	0	81,678018	81,678018	0	0	0	81,678018	81,678018
12	12	94,16	94,16	0	0	81,834456	81,834456	0	0	0	81,834456	81,834456
13	13	94,34	94,34	0	0	81,990894	81,990894	0	0	0	81,990894	81,990894

14	14	94,52	94,52	0	0	82,147332	82,147332	0	0	0	82,147332	82,147332
15	15	94,51	94,51	0	0	82,138641	82,138641	0	0	0	82,138641	82,138641
16	16	94,51	94,51	0	0	82,138641	82,138641	0	0	0	82,138641	82,138641
17	17	94,51	94,51	0	0	82,138641	82,138641	0	0	0	82,138641	82,138641
18	18	94,5	94,5	0	0	82,12995	82,12995	0	0	0	82,12995	82,12995
19	19	94,5	94,5	0	0	82,12995	82,12995	0	0	0	82,12995	82,12995
20	20	94,5	94,5	0	0	82,12995	82,12995	0	0	0	82,12995	82,12995
21	21	94,5	94,5	0	0	82,12995	82,12995	0	0	0	82,12995	82,12995
22	22	94,5	94,5	0	0	82,12995	82,12995	0	0	0	82,12995	82,12995
23	23	94,5	94,5	0	0	82,12995	82,12995	0	0	0	82,12995	82,12995
24	24	94,51	94,51	0	0	82,138641	82,138641	0	0	0	82,138641	82,138641
25	25	94,51	94,51	0	0	82,138641	82,138641	0	0	0	82,138641	82,138641
26	26	94,52	94,52	0	0	82,147332	82,147332	0	0	0	82,147332	82,147332
27	27	94,52	94,52	0	0	82,147332	82,147332	0	0	0	82,147332	82,147332
28	28	94,53	94,53	0	0	82,156023	82,156023	0	0	0	82,156023	82,156023
28,6	28,6	94,53	94,53	0	0	82,156023	82,156023	0	0	0	82,156023	82,156023
29,1	29,1	94,53	94,53	0	0	82,156023	82,156023	0	0	0	82,156023	82,156023
29,6	29,6	94,53	94,53	0	0	82,156023	82,156023	0	0	0	82,156023	82,156023
30,1	30,1	94,54	94,54	0	0	82,164714	82,164714	0	0	0	82,164714	82,164714

30,6	30,6	94,54	94,54	0	0	82,164714	82,164714	0	0	0	82,164714	82,164714
30,6	30,6	94,54	94,54	0	0	82,164714	82,164714	0	0	0	82,164714	82,164714
31,1	31,1	94,54	94,54	0	0	82,164714	82,164714	0	0	0	82,164714	82,164714
31,6	31,6	94,55	94,55	0	0	82,173405	82,173405	0	0	0	82,173405	82,173405
32,1	32,1	94,56	94,56	1	1	82,182096	82,182096	-4,2844265	-4,284426504	0	86,4665225	86,4665225
32,6	32,6	94,56	94,56	8	8	82,182096	82,182096	13,71563537	13,71563537	0	68,46646063	68,46646063
33,1	33,1	94,57	94,57	18	18	82,190787	82,190787	20,73520951	20,73520951	0	61,45557749	61,45557749
33,5	33,5	94,58	94,58	27	27	82,199478	82,199478	24,24499658	24,24499658	0	57,95448142	57,95448142
33,7	33,7	94,59	94,59	32	32	82,208169	82,208169	25,71567662	25,71567662	0	56,49249238	56,49249238
34	34	94,6	94,6	37	37	82,21686	82,21686	26,97240113	26,97240113	0	55,24445887	55,24445887
34,2	34,2	94,6	94,6	41	41	82,21686	82,21686	27,86099602	27,86099602	0	54,35586398	54,35586398
34,5	34,5	94,61	94,61	46	46	82,225551	82,225551	28,85705915	28,85705915	0	53,36849185	53,36849185
34,7	34,7	94,61	94,61	50	50	82,225551	82,225551	29,57882704	29,57882704	0	52,64672396	52,64672396
35	35	94,62	94,62	55	55	82,234242	82,234242	30,40385101	30,40385101	0	51,83039099	51,83039099
35,2	35,2	94,62	94,62	60	60	82,234242	82,234242	31,1570389	31,1570389	0	51,0772031	51,0772031
35,5	35,5	94,63	94,63	64	64	82,242933	82,242933	31,71569724	31,71569724	0	50,52723576	50,52723576
35,7	35,7	94,64	94,64	69	69	82,251624	82,251624	32,36684622	32,36684622	0	49,88477778	49,88477778
36	36	94,64	94,64	74	74	82,251624	82,251624	32,97242176	32,97242176	0	49,27920224	49,27920224
36,2	36,2	94,65	94,65	78	78	82,260315	82,260315	33,42811644	33,42811644	0	48,83219856	48,83219856

36,5	36,5	94,65	94,65	83	83	82,260315	82,260315	33,96594157	33,96594157	0	48,29437343	48,29437343
36,7	36,7	94,66	94,66	88	88	82,269006	82,269006	34,47229643	34,47229643	0	47,79670957	47,79670957
37	37	94,66	94,66	93	93	82,269006	82,269006	34,95066123	34,95066123	0	47,31834477	47,31834477
37,2	37,2	94,67	94,67	97	97	82,277697	82,277697	35,31518667	35,31518667	0	46,96251033	46,96251033
37,5	37,5	94,68	94,68	102	102	82,286388	82,286388	35,75026316	35,75026316	0	46,53612484	46,53612484
37,7	37,7	94,68	94,68	107	107	82,286388	82,286388	36,16451445	36,16451445	0	46,12187355	46,12187355
38	38	94,69	94,69	112	112	82,295079	82,295079	36,55984343	36,55984343	0	45,73523557	45,73523557
38,2	38,2	94,69	94,69	117	117	82,295079	82,295079	36,93790351	36,93790351	0	45,35717549	45,35717549
38,5	38,5	94,7	94,7	122	122	82,30377	82,30377	37,30014046	37,30014046	0	45,00362954	45,00362954
38,7	38,7	94,7	94,7	126	126	82,30377	82,30377	37,57939694	37,57939694	0	44,72437306	44,72437306
39	39	94,71	94,71	131	131	82,312461	82,312461	37,91625657	37,91625657	0	44,39620443	44,39620443
39,2	39,2	94,71	94,71	136	136	82,312461	82,312461	38,24049672	38,24049672	0	44,07196428	44,07196428
39,5	39,5	94,72	94,72	141	141	82,321152	82,321152	38,55302886	38,55302886	0	43,76812314	43,76812314
39,7	39,7	94,73	94,73	146	146	82,329843	82,329843	38,85466913	38,85466913	0	43,47517387	43,47517387
40	40	94,73	94,73	151	151	82,329843	82,329843	39,14615122	39,14615122	0	43,18369178	43,18369178
40,2	40,2	94,74	94,74	156	156	82,338534	82,338534	39,42813707	39,42813707	0	42,91039693	42,91039693
40,5	40,5	94,74	94,74	161	161	82,338534	82,338534	39,70122596	39,70122596	0	42,63730804	42,63730804
40,7	40,7	94,75	94,75	166	166	82,347225	82,347225	39,96596219	39,96596219	0	42,38126281	42,38126281
41	41	94,75	94,75	171	171	82,347225	82,347225	40,22284157	40,22284157	0	42,12438343	42,12438343

41,2	41,2	94,76	94,76	176	176	82,355916	82,355916	40,47231705	40,47231705	0	41,88359895	41,88359895
41,5	41,5	94,76	94,76	181	181	82,355916	82,355916	40,7148035	40,7148035	0	41,6411125	41,6411125
41,7	41,7	94,76	94,76	186	186	82,355916	82,355916	40,95068185	40,95068185	0	41,40523415	41,40523415
42	42	94,76	94,76	191	191	82,355916	82,355916	41,18030274	41,18030274	0	41,17561326	41,17561326
42,2	42,2	94,76	94,76	196	196	82,355916	82,355916	41,40398961	41,40398961	0	40,95192639	40,95192639
42,5	42,5	94,77	94,77	201	201	82,364607	82,364607	41,62204144	41,62204144	0	40,74256556	40,74256556
42,7	42,7	94,77	94,77	206	206	82,364607	82,364607	41,83473519	41,83473519	0	40,52987181	40,52987181
43	43	94,77	94,77	211	211	82,364607	82,364607	42,04232787	42,04232787	0	40,32227913	40,32227913
43,2	43,2	94,77	94,77	217	217	82,364607	82,364607	42,28504097	42,28504097	0	40,07956603	40,07956603
43,5	43,5	94,78	94,78	222	222	82,373298	82,373298	42,48222945	42,48222945	0	39,89106855	39,89106855
43,7	43,7	94,78	94,78	227	227	82,373298	82,373298	42,67502584	42,67502584	0	39,69827216	39,69827216
44	44	94,78	94,78	232	232	82,373298	82,373298	42,86362153	42,86362153	0	39,50967647	39,50967647
44,2	44,2	94,78	94,78	237	237	82,373298	82,373298	43,04819569	43,04819569	0	39,32510231	39,32510231
44,5	44,5	94,78	94,78	242	242	82,373298	82,373298	43,22891624	43,22891624	0	39,14438176	39,14438176
44,7	44,7	94,79	94,79	248	248	82,381989	82,381989	43,44091541	43,44091541	0	38,94107359	38,94107359
45	45	94,79	94,79	253	253	82,381989	82,381989	43,61369959	43,61369959	0	38,76828941	38,76828941
45,2	45,2	94,79	94,79	258	258	82,381989	82,381989	43,78310226	43,78310226	0	38,59888674	38,59888674
45,5	45,5	94,79	94,79	263	263	82,381989	82,381989	43,94925323	43,94925323	0	38,43273577	38,43273577
45,7	45,7	94,8	94,8	268	268	82,39068	82,39068	44,112275	44,112275	0	38,278405	38,278405

46	46	94,8	94,8	274	274	82,39068	82,39068	44,30393301	44,30393301	0	38,08674699	38,08674699
46,2	46,2	94,8	94,8	279	279	82,39068	82,39068	44,46046892	44,46046892	0	37,93021108	37,93021108
46,5	46,5	94,81	94,81	284	284	82,399371	82,399371	44,6142243	44,6142243	0	37,7851467	37,7851467
46,7	46,7	94,81	94,81	290	290	82,399371	82,399371	44,79519674	44,79519674	0	37,60417426	37,60417426
46,8	46,8	94,81	94,81	291	291	82,399371	82,399371	44,82499436	44,82499436	0	37,57437664	37,57437664
47,8	47,8	94,26	94,26	320	320	81,921366	81,921366	45,6473137	45,6473137	0	36,2740523	36,2740523
48,8	48,8	94,31	94,31	360	360	81,964821	81,964821	46,66686721	46,66686721	0	35,29795379	35,29795379
49,6	49,6	94,34	94,34	400	400	81,990894	81,990894	47,57888891	47,57888891	0	34,41200509	34,41200509
50,6	50,6	89,29	94,38	434	451	77,601939	82,025658	48,28506159	48,61765708	-0,332595488	29,31687741	33,40800092
51	51	87,79	94,4	438	469	76,298289	82,04304	48,36447683	48,95642118	-0,591944352	27,93381217	33,08661882
52	52	85,62	94,44	454	521	74,412342	82,077804	48,67504646	49,86659701	-1,191550546	25,73729554	32,21120699
53	53	85,3	94,48	469	574	74,13423	82,112568	48,95642118	50,70520408	-1,748782896	25,17780882	31,40736392
54	54	85,3	94,52	484	628	74,13423	82,147332	49,22893687	51,48348969	-2,254552819	24,90529313	30,66384231
55	55	85,3	94,56	499	682	74,13423	82,182096	49,49313438	52,19753522	-2,704400838	24,64109562	29,98456078
56	56	85,3	94,6	514	736	74,13423	82,21686	49,74950653	52,85714165	-3,107635123	24,38472347	29,35971835
57	57	85,31	94,64	529	790	74,142921	82,251624	49,99850356	53,47002508	-3,471521519	24,14441744	28,78159892
57,2	58	85,31	94,65	545	800	74,142921	82,260315	50,25643549	53,57890953	-3,322474041	23,88648551	28,68140547
58,2	58,9	85,31	89,55	560	851	74,142921	77,827905	50,49145988	54,11386616	-3,62240628	23,65146112	23,71403884
59,2	59,9	85,31	85,85	580	895	74,142921	74,612235	50,79521737	54,55023897	-3,7550216	23,34770363	20,06199603

60,2	60,9	85,31	85,36	609	934	74,142921	74,186376	51,21755479	54,91944944	-3,701894656	22,92536621	19,26692656
61,2	61,9	85,31	85,35	643	970	74,142921	74,177685	51,68781546	55,24682375	-3,559008292	22,45510554	18,93086125
62,2	62,9	85,32	85,36	678	1005	74,151612	74,186376	52,14661625	55,5536579	-3,407041649	22,00499575	18,6327181
63,2	63,9	85,32	85,36	714	1040	74,151612	74,186376	52,59445059	55,84998708	-3,255536485	21,55716141	18,33638892
64,2	64,9	85,32	85,36	751	1074	74,151612	74,186376	53,0317851	56,12845083	-3,096665727	21,1198269	18,05792517
65,2	65,9	85,33	85,36	788	1108	74,160303	74,186376	53,44808286	56,39823508	-2,95015222	20,71222014	17,78814092
66,2	66,9	85,33	85,37	825	1142	74,160303	74,195067	53,84527516	56,6598646	-2,814589432	20,31502784	17,5352024
67,2	67,9	85,33	85,37	862	1176	74,160303	74,195067	54,22503897	56,91381793	-2,688778957	19,93526403	17,28124907
68,2	68,9	85,34	85,37	899	1210	74,168994	74,195067	54,5888397	57,1605327	-2,571693	19,5801543	17,0345343
69,2	69,9	85,34	85,38	936	1244	74,168994	74,203758	54,93796538	57,40041015	-2,462444768	19,23102862	16,80334785
70,2	70,9	85,34	85,38	973	1278	74,168994	74,203758	55,27355419	57,63381906	-2,36026487	18,89543981	16,56993894
71,2	71,9	85,35	85,38	1010	1312	74,177685	74,203758	55,5966168	57,86109914	-2,264482346	18,5810682	16,34265886
72,2	72	85,35	85,38	1011	1346	74,177685	74,203758	55,60518305	58,08256404	-2,477380992	18,57250195	16,12119396
73,2	72,2	85,35	85,39	1018	1380	74,177685	74,212449	55,66491064	58,29850393	-2,633593286	18,51277436	15,91394507
74,2	72,5	85,35	85,39	1022	1414	74,177685	74,212449	55,69885657	58,50918777	-2,810331203	18,47882843	15,70326123
75,2	72,7	85,35	85,39	1025	1447	74,177685	74,212449	55,72422894	58,70888527	-2,984656332	18,45345606	15,50356373
76,2	73	85,35	85,39	1029	1481	74,177685	74,212449	55,75794349	58,90992627	-3,151982785	18,41974151	15,30252273
77,2	73,2	85,35	85,4	1033	1515	74,177685	74,22114	55,79152723	59,10640386	-3,314876631	18,38615777	15,11473614
78,2	73,5	85,35	85,4	1037	1549	74,177685	74,22114	55,82498119	59,29852063	-3,47353944	18,35270381	14,92261937

79,2	73,7	85,35	85,4	1041	1582	74,177685	74,22114	55,85830635	59,48099599	-3,62268964	18,31937865	14,74014401
80,2	74	85,35	85,4	1045	1616	74,177685	74,22114	55,89150371	59,66506221	-3,773558506	18,28618129	14,55607779
80,3	74,2	85,35	85,4	1049	1621	74,177685	74,22114	55,92457423	59,69180366	-3,767229427	18,25311077	14,52933634
81,3	74,5	85,35	85,41	1053	1655	74,177685	74,229831	55,9575189	59,87148703	-3,913968138	18,2201661	14,35834397
82,3	74,7	85,35	85,41	1057	1688	74,177685	74,229831	55,99033865	60,04238974	-4,052051092	18,18734635	14,18744126
83,3	75	85,35	85,41	1060	1721	74,177685	74,229831	56,01487206	60,20998348	-4,195111416	18,16281294	14,01984752
84,3	75,2	85,35	85,42	1064	1754	74,177685	74,238522	56,04747549	60,37439395	-4,326918455	18,13020951	13,86412805
85,3	75,5	85,35	85,42	1068	1785	74,177685	74,238522	56,07995658	60,52604643	-4,446089846	18,09772842	13,71247557
86,3	75,7	85,35	85,42	1072	1816	74,177685	74,238522	56,11231625	60,67508771	-4,562771465	18,06536875	13,56343429
87,3	76	85,35	85,42	1076	1846	74,177685	74,238522	56,14455539	60,8169183	-4,672362911	18,03312961	13,4216037
88,3	76,2	85,35	85,42	1080	1875	74,177685	74,238522	56,17667491	60,95184702	-4,775172113	18,00101009	13,28667498
89,3	76,5	85,35	85,43	1084	1903	74,177685	74,247213	56,20867568	61,08015726	-4,871481575	17,96900932	13,16705574
90,3	76,7	85,35	85,43	1088	1932	74,177685	74,247213	56,24055859	61,2110749	-4,970516311	17,93712641	13,0361381
91,3	77	85,38	85,43	1092	1960	74,203758	74,247213	56,2723245	61,33562669	-5,063302193	17,9314335	12,91158631
92,3	77,2	85,4	85,43	1096	1989	74,22114	74,247213	56,30397426	61,46276486	-5,1587906	17,91716574	12,78444814
93,3	77,5	85,43	85,43	1100	2017	74,247213	74,247213	56,33550872	61,58377212	-5,248263401	17,91170428	12,66344088
94,3	77,7	85,46	85,44	1104	2045	74,273286	74,255904	56,36692872	61,70311109	-5,336182369	17,90635728	12,55279291
95,3	78	85,48	85,44	1108	2074	74,290668	74,255904	56,39823508	61,82500181	-5,42676673	17,89243292	12,43090219
96,3	78,2	85,51	85,44	1112	2102	74,316741	74,255904	56,42942863	61,94108286	-5,511654233	17,88731237	12,31482114

97,3	78,5	85,53	85,44	1116	2102	74,334123	74,255904	56,46051017	61,94108286	-5,480572692	17,87361283	12,31482114
98,3	78,5	85,54	85,44	1116	2158	74,342814	74,255904	56,46051017	62,16867682	-5,708166647	17,88230383	12,08722718
99,3	78,7	85,56	85,45	1120	2186	74,360196	74,264595	56,49148051	62,28026842	-5,788787911	17,86871549	11,98432658
100,3	79	85,59	85,45	1124	2214	74,386269	74,264595	56,52234043	62,39043972	-5,86809929	17,86392857	11,87415528
101,3	79,2	85,61	85,45	1128	2242	74,403651	74,264595	56,55309073	62,49922643	-5,946135702	17,85056027	11,76536857
102,3	79,5	85,64	85,45	1132	2270	74,429724	74,264595	56,58373218	62,60666292	-6,022930739	17,84599182	11,65793208
103,3	79,7	85,67	85,45	1136	2298	74,455797	74,264595	56,61426555	62,71278229	-6,098516742	17,84153145	11,55181271
104,3	80	85,69	85,46	1140	2326	74,473179	74,273286	56,64469159	62,81761644	-6,172924853	17,82848741	11,45566956
105,3	80,2	85,72	85,46	1144	2354	74,499252	74,273286	56,67501106	62,92119614	-6,24618508	17,82424094	11,35208986
106,3	80,3	85,72	85,46	1145	2382	74,499252	74,273286	56,68257436	63,02355105	-6,340976686	17,81667764	11,24973495
107,3	81,3	85,75	85,46	1166	2409	74,525325	74,273286	56,83989604	63,12111726	-6,281221221	17,68542896	11,15216874
108,3	82,3	85,76	85,46	1196	2437	74,534016	74,273286	57,0597944	63,22114875	-6,161354348	17,4742216	11,05213725
109,3	83,3	85,77	85,47	1230	2465	74,542707	74,281977	57,3024408	63,32003747	-6,017596671	17,2402662	10,96193953
110,3	84,3	85,78	85,47	1265	2493	74,551398	74,281977	57,54531605	63,41780922	-5,872493173	17,00608195	10,86416778
111,3	85,3	85,79	85,47	1300	2521	74,560089	74,281977	57,78156229	63,51448896	-5,732926676	16,77852671	10,76748804
112,3	86,3	85,81	85,47	1335	2548	74,577471	74,281977	58,01153179	63,60670424	-5,595172447	16,56593921	10,67527276
113,3	87,3	85,82	85,47	1370	2576	74,586162	74,281977	58,23554947	63,70130846	-5,46575899	16,35061253	10,58066854
114,3	88,3	85,83	85,48	1405	2603	74,594853	74,290668	58,45391564	63,79156508	-5,337649435	16,14093736	10,49910292
115,3	89,3	85,85	85,48	1439	2631	74,612235	74,290668	58,66089512	63,88418102	-5,223285893	15,95133988	10,40648698

116,3	90,3	85,86	85,48	1474	2659	74,620926	74,290668	58,86891543	63,9758165	-5,106901071	15,75201057	10,3148515
117,3	91,3	85,87	85,48	1508	2686	74,629617	74,290668	59,06631554	64,06326997	-4,996954433	15,56330146	10,22739803
118,3	92,3	85,88	85,49	1543	2714	74,638308	74,299359	59,26492602	64,15303877	-4,888112755	15,37338198	10,14632023
119,3	93,3	85,89	85,49	1577	2741	74,646999	74,299359	59,45359426	64,23872871	-4,785134457	15,19340474	10,06063029
120,3	94,3	85,91	85,49	1612	2769	74,664381	74,299359	59,64360941	64,32670537	-4,683095957	15,02077159	9,972653631
121,3	95,3	85,92	85,49	1646	2796	74,673072	74,299359	59,82428558	64,4107015	-4,586415915	14,84878642	9,8886575
122,3	96,3	85,93	85,5	1681	2823	74,681763	74,30805	60,00641854	64,49389039	-4,48747185	14,67534446	9,814159606
123,3	97,3	85,94	85,5	1715	2851	74,690454	74,30805	60,17975225	64,57932415	-4,3995719	14,51070175	9,728725849
124,3	98,3	85,96	85,5	1750	2878	74,707836	74,30805	60,35463093	64,66091575	-4,306284822	14,35320507	9,647134252
125,3	99,3	85,97	85,5	1784	2905	74,716527	74,30805	60,52119566	64,74174546	-4,220549798	14,19533134	9,566304545
126,3	100,3	85,98	85,5	1818	2933	74,725218	74,30805	60,68461572	64,82477919	-4,140163461	14,04060228	9,483270815
127,3	101,3	85,99	85,51	1853	2960	74,733909	74,316741	60,84968038	64,90410009	-4,054419704	13,88422862	9,412640913
127,6	102,3	86,01	85,51	1887	2966	74,751291	74,316741	61,00707017	64,92162868	-3,914558505	13,74422083	9,395112321
128,6	103,3	86,02	85,51	1921	2995	74,759982	74,316741	61,16164928	65,0058534	-3,844204118	13,59833272	9,310887601
128,8	104,3	86,03	85,51	1956	3000	74,768673	74,316741	61,31794293	65,02029244	-3,702349509	13,45073007	9,296448565
129	105,3	86,04	85,51	1990	3005	74,777364	74,316741	61,4671158	65,03470743	-3,567591624	13,3102482	9,282033574
129,3	106,3	86,06	85,51	2024	3009	74,794746	74,316741	61,61376146	65,04622216	-3,432460699	13,18098454	9,27051884
129,5	107,3	86,07	85,51	2058	3012	74,803437	74,316741	61,75796411	65,05484817	-3,296884059	13,04547289	9,26189283
129,8	108,3	86,08	85,51	2093	3015	74,812128	74,316741	61,90394059	65,06346559	-3,159525004	12,90818741	9,253275408

130	109,3	86,09	85,51	2127	3019	74,820819	74,316741	62,0434274	65,07494216	-3,031514762	12,7773916	9,24179884
130,3	110,3	86,1	85,51	2161	3022	74,82951	74,316741	62,1807021	65,08353961	-2,902837508	12,6488079	9,233201389
130,5	111,3	86,12	85,51	2195	3026	74,846892	74,316741	62,31583377	65,09498961	-2,77915584	12,53105823	9,221751387
130,8	112,3	86,13	85,51	2229	3029	74,855583	74,316741	62,44888829	65,10356719	-2,654678894	12,40669471	9,213173814
131	113,3	86,14	85,51	2263	3032	74,864274	74,316741	62,57992855	65,11213627	-2,532207718	12,28434545	9,204604732
131,3	114,3	86,15	85,51	2298	3036	74,872965	74,316741	62,71278229	65,12354853	-2,410766243	12,16018271	9,19319247
131,5	115,3	86,16	85,51	2332	3039	74,881656	74,316741	62,83991667	65,13209786	-2,292181197	12,04173933	9,184643136
131,8	116,3	86,18	85,51	2366	3042	74,899038	74,316741	62,96521081	65,14063876	-2,175427954	11,93382719	9,176102237
132	117,3	86,19	85,52	2400	3046	74,907729	74,325432	63,08871723	65,15201353	-2,063296308	11,81901177	9,173418465
132,3	118,3	86,2	85,52	2434	3049	74,91642	74,325432	63,21048622	65,16053482	-1,950048597	11,70593378	9,164897185
132,5	119,3	86,21	85,52	2468	3053	74,925111	74,325432	63,33056599	65,17188349	-1,8413175	11,59454501	9,153548511
132,8	120,3	86,23	85,52	2502	3056	74,942493	74,325432	63,44900277	65,18038524	-1,731382475	11,49349023	9,145046759
133	121,3	86,24	85,52	2536	3059	74,951184	74,325432	63,5658409	65,18887865	-1,623037748	11,3853431	9,136553348
133,3	122,3	86,25	85,52	2570	3063	74,959875	74,325432	63,68112298	65,20019025	-1,519067267	11,27875202	9,125241749
133,5	123,3	86,27	85,52	2604	3066	74,977257	74,325432	63,79488991	65,20866426	-1,413774351	11,18236709	9,11676774
133,8	124,3	86,28	85,52	2638	3070	74,985948	74,325432	63,90718099	65,21995005	-1,312769059	11,07876701	9,105481949
134	125,3	86,29	85,52	2671	3073	74,994639	74,325432	64,01479383	65,22840475	-1,213610917	10,97984517	9,097027252
134,3	126,3	86,31	85,52	2705	3077	75,012021	74,325432	64,12428592	65,23966485	-1,115378932	10,88773508	9,085767153
134,5	127,3	86,32	85,52	2739	3080	75,020712	74,325432	64,23241032	65,24810032	-1,015690001	10,78830168	9,07733168

134,8	128,3	86,34	85,52	2773	3084	75,038094	74,325432	64,33920079	65,25933484	-0,920134056	10,69889321	9,066097156
135	129,3	86,35	85,52	2807	3087	75,046785	74,325432	64,44468984	65,26775118	-0,823061344	10,60209516	9,057680821
135,3	130,3	86,36	85,52	2841	3091	75,055476	74,325432	64,5489088	65,27896025	-0,730051445	10,5065672	9,046471755
135,5	131,3	86,38	85,52	2875	3094	75,072858	74,325432	64,6518879	65,28735753	-0,635469629	10,4209701	9,03807447
135,8	132,3	86,39	85,52	2908	3098	75,081549	74,325432	64,75068012	65,29854125	-0,547861132	10,33086888	9,026890748
136	133,1	86,4	85,52	2937	3101	75,09024	74,325432	64,83657639	65,30691957	-0,470343178	10,25366361	9,018512428
136,3	134,1	86,42	85,53	2972	3105	75,107622	74,334123	64,93912185	65,31807807	-0,378956218	10,16850015	9,016044935
136,5	135,1	86,43	85,53	3009	3108	75,116313	74,334123	65,04622216	65,32643751	-0,280215346	10,07009084	9,007685494
136,8	136,1	86,44	85,53	3046	3112	75,125004	74,334123	65,15201353	65,33757088	-0,185557349	9,972990465	8,996552117
137	137,1	86,46	85,53	3084	3115	75,142386	74,334123	65,25933484	65,34591153	-0,086576686	9,883051156	8,98821147
137,3	138,1	86,47	85,53	3122	3119	75,151077	74,334123	65,36534184	65,3570199	0,008321936	9,785735159	8,977103095
137,5	139,1	86,49	85,53	3160	3122	75,168459	74,334123	65,47006633	65,36534184	0,104724486	9,698392673	8,968781159
137,8	140,1	86,5	85,53	3198	3126	75,17715	74,334123	65,57353897	65,37642533	0,19711364	9,603611034	8,957697675
138	141,1	86,52	85,53	3236	3130	75,194532	74,334123	65,67578933	65,38749464	0,288294695	9,518742669	8,946628364
138,1	142,1	86,54	85,53	3274	3130	75,211914	74,334123	65,77684596	65,38749464	0,389351326	9,435068038	8,946628364
138,3	143,1	86,55	85,53	3312	3134	75,220605	74,334123	65,87673641	65,39854981	0,478186602	9,343868588	8,93557319
138,6	144,1	86,57	85,53	3350	3137	75,237987	74,334123	65,97548729	65,40683193	0,568655353	9,262499712	8,927291065
138,8	145,1	86,58	85,55	3388	3141	75,246678	74,351505	66,0731243	65,41786246	0,655261842	9,173553702	8,933642545
139,1	146,1	86,6	85,57	3426	3145	75,26406	74,368887	66,16967229	65,42887894	0,740793352	9,09438771	8,940008062

139,3	147,1	86,61	85,6	3464	3148	75,272751	74,39496	66,26515529	65,43713211	0,828023182	9,00759571	8,957827891
139,6	147,5	86,62	85,62	3480	3152	75,281442	74,412342	66,30504568	65,44812411	0,856921573	8,976396316	8,96421789
139,8	148,5	61,68	85,64	3480	3156	53,606088	74,429724	66,30504568	65,45910217	0,845943512	12,69895768	8,970621829
140,1	149,5	61,68	85,67	3480	3159	53,606088	74,455797	66,30504568	65,46732659	0,837719093	12,69895768	8,98847041
140,3	150,5	61,68	85,69	3480	3163	53,606088	74,473179	66,30504568	65,47828034	0,826765343	12,69895768	8,99489866
140,6	151,5	61,68	85,72	3480	3167	53,606088	74,499252	66,30504568	65,48922025	0,815825437	12,69895768	9,010031753
140,8	152,5	61,68	85,74	3480	3170	53,606088	74,516634	66,30504568	65,49741611	0,80762957	12,69895768	9,019217887
141,1	153,5	61,68	85,77	3480	3174	53,606088	74,542707	66,30504568	65,50833188	0,796713806	12,69895768	9,034375122
141,3	154,5	61,67	85,79	3480	3178	53,597397	74,560089	66,30504568	65,51923389	0,785811789	12,70764868	9,040855106
141,6	155,5	61,67	85,82	3480	3181	53,597397	74,586162	66,30504568	65,52740141	0,777644278	12,70764868	9,058760595
141,8	156,5	61,67	85,84	3480	3185	53,597397	74,603544	66,30504568	65,53827945	0,766766237	12,70764868	9,065264554
142,1	157,5	61,67	85,87	3480	3189	53,597397	74,629617	66,30504568	65,54914383	0,755901849	12,70764868	9,080473166
142,3	158,5	61,67	85,89	3480	3193	53,597397	74,646999	66,30504568	65,5599946	0,74505108	12,70764868	9,087004396
142,6	159,5	61,67	85,92	3480	3196	53,597397	74,673072	66,30504568	65,56812376	0,73692192	12,70764868	9,104948236
142,8	160,5	61,67	85,94	3480	3200	53,597397	74,690454	66,30504568	65,57895078	0,726094902	12,70764868	9,111503218
143,1	161,5	61,67	85,97	3480	3204	53,597397	74,716527	66,30504568	65,58976427	0,715281409	12,70764868	9,126762725
143,3	162,5	61,67	85,99	3480	3208	53,597397	74,733909	66,30504568	65,60056428	0,704481407	12,70764868	9,133344724
143,6	163,5	61,67	86,02	3480	3211	53,597397	74,759982	66,30504568	65,60865544	0,69639024	12,70764868	9,151326556
143,8	164,5	61,67	86,04	3480	3215	53,597397	74,777364	66,30504568	65,61943192	0,685613768	12,70764868	9,157932084

144,1	165,5	61,67	86,07	3480	3219	53,597397	74,803437	66,30504568	65,63019499	0,674850695	12,70764868	9,173242012
144,3	166,5	61,67	86,09	3480	3223	53,597397	74,820819	66,30504568	65,64094469	0,664100989	12,70764868	9,179874305
144,6	167,5	61,67	86,12	3480	3227	53,597397	74,846892	66,30504568	65,65168107	0,653364615	12,70764868	9,195210932
144,8	168,5	61,67	86,14	3480	3230	53,597397	74,864274	66,30504568	65,65972462	0,645321065	12,70764868	9,204549382
145,1	169,5	61,67	86,17	3480	3234	53,597397	74,890347	66,30504568	65,67043774	0,634607945	12,70764868	9,219909261
145,3	170,5	61,67	86,19	3480	3238	53,597397	74,907729	66,30504568	65,68113762	0,623908067	12,70764868	9,226591384
145,6	171,5	61,67	86,22	3480	3242	53,597397	74,933802	66,30504568	65,69182428	0,613221399	12,70764868	9,241977716
145,8	172,5	61,67	86,25	3480	3246	53,597397	74,959875	66,30504568	65,70249778	0,602547908	12,70764868	9,257377225
146,1	173,5	61,67	86,27	3480	3250	53,597397	74,977257	66,30504568	65,71315812	0,591887562	12,70764868	9,264098879
146,3	174,5	61,67	86,3	3480	3254	53,597397	75,00333	66,30504568	65,72380536	0,581240328	12,70764868	9,279524645
146,6	175,5	61,67	86,32	3480	3258	53,597397	75,020712	66,30504568	65,73443951	0,570606175	12,70764868	9,286272491
146,8	176,5	61,67	86,35	3480	3262	53,597397	75,046785	66,30504568	65,74506061	0,559985069	12,70764868	9,301724385
147,1	177,5	61,67	86,37	3480	3265	53,597397	75,064167	66,30504568	65,7530179	0,552027783	12,70764868	9,3111491
147,3	178,5	61,67	86,4	3480	3269	53,597397	75,09024	66,30504568	65,76361625	0,541429435	12,70764868	9,326623751
147,6	179,5	61,67	86,42	3480	3273	53,597397	75,107622	66,30504568	65,77420164	0,530844047	12,70764868	9,333420363
147,8	180,5	61,67	86,45	3480	3277	53,597397	75,133695	66,30504568	65,7847741	0,520271588	12,70764868	9,348920904
148,1	181,5	61,67	86,47	3480	3281	53,597397	75,151077	66,30504568	65,79533366	0,509712025	12,70764868	9,355743342
148,3	182,5	61,67	86,5	3480	3285	53,597397	75,17715	66,30504568	65,80588035	0,499165329	12,70764868	9,371269645
148,6	183,5	61,67	86,53	3480	3289	53,597397	75,203223	66,30504568	65,81641422	0,488631467	12,70764868	9,386808783

149,6	184,5	61,67	86,55	3480	3311	53,597397	75,220605	66,30504568	65,87412243	0,430923253	12,70764868	9,34648257
150,6	185,5	61,67	86,56	3480	3341	53,597397	75,229296	66,30504568	65,95220053	0,352845153	12,70764868	9,27709547
151,6	186,5	61,67	86,58	3480	3375	53,597397	75,246678	66,30504568	66,03984595	0,265199735	12,70764868	9,206832051
152,6	187,5	61,67	86,59	3480	3411	53,597397	75,255369	66,30504568	66,13168978	0,173355903	12,70764868	9,123679219
153,6	188,5	61,67	86,61	3480	3448	53,597397	75,272751	66,30504568	66,22508022	0,079965465	12,70764868	9,047670781
154,3	188,8	61,67	86,62	3480	3475	53,597397	75,281442	66,30504568	66,29259967	0,012446012	12,70764868	8,988842329
155,3	189,8	61,67	61,67	3480	3475	53,597397	53,597397	66,30504568	66,29259967	0,012446012	12,70764868	12,69520267
156,3	190,5	61,67	61,67	3480	3475	53,597397	53,597397	66,30504568	66,29259967	0,012446012	12,70764868	12,69520267
157,3	191,5	86,63	61,67	3488	3475	75,290133	53,597397	66,32492216	66,29259967	0,032322485	8,965210844	12,69520267
158,3	192,5	86,73	61,67	3504	3475	75,377043	53,597397	66,3645387	66,29259967	0,07193903	9,012504299	12,69520267
159,3	193,5	86,84	61,67	3521	3475	75,472644	53,597397	66,40643356	66,29259967	0,113833887	9,066210441	12,69520267
160,3	194,5	86,94	61,67	3537	3475	75,559554	53,597397	66,44567964	66,29259967	0,153079973	9,113874355	12,69520267
161,3	195,5	87,04	61,67	3554	3475	75,646464	53,597397	66,48718456	66,29259967	0,19458489	9,159279439	12,69520267
162,3	196,5	87,15	61,67	3570	3475	75,742065	53,597397	66,52606705	66,29259967	0,233467381	9,215997948	12,69520267
163,3	197,5	87,25	61,67	3587	3475	75,828975	53,597397	66,56718922	66,29259967	0,274589549	9,26178578	12,69520267
164,3	198,5	87,36	61,67	3604	3475	75,924576	53,597397	66,60811696	66,29259967	0,315517284	9,316459044	12,69520267
165,3	199,5	87,47	61,67	3621	3475	76,020177	53,597397	66,64885209	66,29259967	0,356252418	9,37132491	12,69520267
166,3	199,6	87,47	61,67	3622	3475	76,020177	53,597397	66,65124231	66,29259967	0,358642644	9,368934685	12,69520267
167,3	200,6	87,58	61,67	3640	3475	76,115778	53,597397	66,69415389	66,29259967	0,401554216	9,421624113	12,69520267

168,3	201,6	87,69	61,67	3657	3475	76,211379	53,597397	66,73448708	66,29259967	0,441887412	9,476891917	12,69520267
169,3	202,6	87,8	61,67	3675	3475	76,30698	53,597397	66,77698897	66,29259967	0,484389298	9,529991031	12,69520267
170,3	203,6	87,9	61,67	3693	3475	76,39389	53,597397	66,81928319	66,29259967	0,526683519	9,57460681	12,69520267
171,3	204,6	88,01	61,67	3711	3475	76,489491	53,597397	66,86137177	66,29259967	0,568772094	9,628119234	12,69520267
172,3	205,6	88,13	61,67	3729	3475	76,593783	53,597397	66,90325669	66,29259967	0,610657015	9,690526314	12,69520267
173,3	206,6	88,18	61,67	3748	3475	76,637238	53,597397	66,94724977	66,29259967	0,654650101	9,689988227	12,69520267
174,3	207,6	88,18	61,67	3766	3475	76,637238	53,597397	66,9887222	66,29259967	0,696122526	9,648515803	12,69520267
175,3	208,6	88,19	61,67	3785	3475	76,645929	53,597397	67,03228415	66,29259967	0,739684477	9,613644852	12,69520267
176,3	209,6	88,2	61,67	3804	3475	76,65462	53,597397	67,07562797	66,29259967	0,783028302	9,578992027	12,69520267
177,3	210,6	88,2	61,67	3824	3475	76,65462	53,597397	67,12101979	66,29259967	0,82842012	9,533600208	12,69520267
178,3	211,6	88,21	61,67	3843	3475	76,663311	53,597397	67,16392266	66,29259967	0,871322986	9,499388342	12,69520267
179,3	212,6	88,22	61,67	3863	3475	76,672002	53,597397	67,20885502	66,29259967	0,916255348	9,463146981	12,69520267
180,3	213,6	88,22	61,67	3883	3475	76,672002	53,597397	67,25355535	66,29259967	0,96095568	9,418446649	12,69520267
181,3	214,6	88,23	61,66	3902	3475	76,680693	53,588706	67,29580792	66,29259967	1,003208249	9,38488508	12,70389367
182,3	215,6	88,24	61,66	3923	3475	76,689384	53,588706	67,34226942	66,29259967	1,049669754	9,347114575	12,70389367
183,3	216,6	88,24	61,66	3943	3475	76,689384	53,588706	67,38628783	66,29259967	1,093688155	9,303096174	12,70389367
184,3	217,6	88,25	61,66	3963	3475	76,698075	53,588706	67,43008352	66,29259967	1,137483847	9,267991482	12,70389367
185,3	218,6	88,26	61,66	3984	3475	76,706766	53,588706	67,47583176	66,29259967	1,183232085	9,230934244	12,70389367
186,3	219,6	88,26	61,66	4005	3475	76,706766	53,588706	67,52133948	66,29259967	1,228739812	9,185426516	12,70389367

186,9	220,1	88,27	61,66	4015	3475	76,715457	53,588706	67,54292603	66,29259967	1,250326357	9,172530971	12,70389367
187,9	220,4	88,27	61,66	4021	3475	76,715457	53,588706	67,55585216	66,29259967	1,263252492	9,159604837	12,70389367
188,9	220,6	88,28	61,66	4026	3475	76,724148	53,588706	67,56660922	66,29259967	1,274009546	9,157538783	12,70389367
189,9	220,9	88,28	61,66	4031	3475	76,724148	53,588706	67,57735292	66,29259967	1,284753248	9,14679508	12,70389367
190,9	221,1	88,28	61,66	4037	3475	76,724148	53,588706	67,59022779	66,29259967	1,297628114	9,133920214	12,70389367
191,9	221,4	88,28	61,66	4042	3475	76,724148	53,588706	67,60094223	66,29259967	1,308342561	9,123205768	12,70389367
192,9	221,6	88,28	61,66	4047	3475	76,724148	53,588706	67,61164343	66,29259967	1,319043761	9,112504568	12,70389367
193,9	221,9	88,28	61,66	4052	3475	76,724148	53,588706	67,62233142	66,29259967	1,329731749	9,10181658	12,70389367
194,9	222,1	88,29	61,66	4058	3475	76,732839	53,588706	67,63513961	66,29259967	1,342539938	9,09769939	12,70389367
195,9	222,4	88,29	61,66	4063	3475	76,732839	53,588706	67,64579864	66,29259967	1,353198972	9,087040357	12,70389367
196,9	222,6	88,29	61,66	4068	3475	76,732839	53,588706	67,65644457	66,29259967	1,363844896	9,076394432	12,70389367
97,3	222,9	88,29	61,66	4074	3475	76,732839	53,588706	67,66920242	66,29259967	1,376602747	9,063636582	12,70389367
198,3	223,1	88,29	86,63	4079	3484	76,732839	75,290133	67,67981962	66,31498962	1,364829991	9,053019384	8,975143375
199,3	223,4	88,29	86,73	4084	3500	76,732839	75,377043	67,69042381	66,35465155	1,335772257	9,042415194	9,02239145
200,3	223,6	88,3	86,83	4090	3516	76,74153	75,463953	67,70313171	66,39413258	1,308999136	9,038398288	9,069820424
201,3	223,9	88,3	86,94	4095	3532	76,74153	75,559554	67,7137074	66,43343435	1,280273054	9,0278226	9,126119654
202,3	224,1	88,3	87,04	4100	3549	76,74153	75,646464	67,72427018	66,47499788	1,249272306	9,017259816	9,171466122
203,3	224,4	88,3	87,15	4106	3565	76,74153	75,742065	67,73692853	66,51393503	1,222993509	9,004601466	9,228129975
204,3	224,6	88,31	87,25	4111	3582	76,750221	75,828975	67,74746304	66,55511473	1,192348306	9,002757963	9,273860269

205,3	224,9	88,31	87,36	4116	3599	76,750221	75,924576	67,75798473	66,59609946	1,161885274	8,992236265	9,328476539
206,3	225,1	88,31	87,46	4122	3616	76,750221	76,011486	67,77059391	66,63689105	1,13370286	8,979627086	9,374594946
206,3	225,4	88,31	87,47	4127	3616	76,750221	76,020177	67,78108755	66,63689105	1,144196497	8,969133449	9,383285946
207,3	225,6	88,31	87,58	4132	3634	76,750221	76,115778	67,79156848	66,67987365	1,111694829	8,958652518	9,435904347
208,3	225,9	88,31	87,68	4138	3652	76,750221	76,202688	67,80412887	66,72264387	1,081484997	8,946092129	9,480044126
209,3	226,1	88,32	87,79	4143	3670	76,758912	76,298289	67,81458196	66,76520381	1,049378151	8,944330042	9,533085193
210,3	226,4	88,32	87,9	4148	3687	76,758912	76,39389	67,82502244	66,80520806	1,019814372	8,933889563	9,588681935
211,3	226,6	88,32	88,01	4154	3706	76,758912	76,489491	67,83753441	66,84970101	0,987833404	8,921377588	9,639789993
212,3	226,9	88,32	88,12	4159	3724	76,758912	76,585092	67,84794726	66,8916423	0,95630496	8,910964739	9,693449699
213,3	227,1	88,32	88,18	4165	3743	76,758912	76,637238	67,86042617	66,9356943	0,924731863	8,898485833	9,701543696
214,3	227,4	88,32	88,18	4170	3761	76,758912	76,637238	67,87081153	66,977222	0,893589535	8,888100469	9,660016004
215,3	227,6	88,33	88,19	4175	3780	76,767603	76,645929	67,88118445	67,02084171	0,860342736	8,88641855	9,625087286
216,3	227,9	88,33	88,2	4181	3799	76,767603	76,65462	67,89361557	67,06424273	0,829372839	8,873987432	9,590377271
217,3	228,1	88,33	88,2	4186	3819	76,767603	76,65462	67,90396121	67,10969413	0,79426708	8,863641787	9,544925867
218,3	228,4	88,33	88,21	4192	3838	76,767603	76,663311	67,91635969	67,15265303	0,763706657	8,851243313	9,51065797
219,3	228,6	88,33	88,22	4197	3858	76,767603	76,672002	67,9266782	67,19764378	0,729034425	8,840924799	9,474358224
220,3	228,9	88,34	88,22	4202	3877	76,776294	76,672002	67,93698443	67,24016947	0,696814957	8,839309571	9,431832528
221,3	229,1	88,34	88,23	4208	3897	76,776294	76,680693	67,94933573	67,2847088	0,664626923	8,826958273	9,395984196
222,3	229,4	88,34	88,24	4213	3918	76,776294	76,689384	67,95961503	67,33122976	0,62838527	8,81667897	9,35815424

223,3	229,6	88,34	88,24	4219	3938	76,776294	76,689384	67,9719341	67,37530419	0,596629909	8,804359898	9,314079807
224,3	229,9	88,35	88,25	4224	3958	76,784985	76,698075	67,98218662	67,41915535	0,563031269	8,80279838	9,278919649
225,3	230,1	88,35	88,26	4229	3979	76,784985	76,706766	67,99242701	67,46496123	0,527465781	8,792557991	9,241804772
226,3	230,4	88,35	88,26	4235	4000	76,784985	76,706766	68,00469951	67,51052599	0,494173516	8,780285493	9,196240009
226,8	230,6	88,35	88,27	4240	4010	76,784985	76,715457	68,01491331	67,53213949	0,482773828	8,770071687	9,183317515
227,1	230,9	88,35	88,27	4246	4016	76,784985	76,715457	68,02715399	67,54508173	0,482072269	8,757831006	9,170375275
227,3	231,1	88,36	88,27	4251	4021	76,793676	76,715457	68,03734136	67,55585216	0,481489192	8,756334644	9,159604837
227,6	231,4	88,36	88,28	4256	4026	76,793676	76,724148	68,04751674	67,56660922	0,480907525	8,746159258	9,157538783
227,8	231,6	88,36	88,28	4262	4032	76,793676	76,724148	68,05971144	67,57950006	0,480211376	8,733964563	9,144647939
228,1	231,9	88,36	88,28	4267	4037	76,793676	76,724148	68,06986058	67,59022779	0,479632791	8,723815423	9,133920214
228,3	232,1	88,36	88,28	4273	4042	76,793676	76,724148	68,08202386	67,60094223	0,481081625	8,711652143	9,123205768
228,6	232,4	88,36	88,28	4278	4047	76,793676	76,724148	68,09214689	67,61164343	0,480503453	8,701529115	9,112504568
228,8	232,6	88,37	88,29	4284	4053	76,802367	76,732839	68,10427891	67,62446743	0,479811478	8,698088088	9,108371565
229,1	232,9	88,37	88,29	4289	4058	76,802367	76,732839	68,11437596	67,63513961	0,479236353	8,687991038	9,09769939
229,3	233,1	88,37	88,29	4295	4063	76,802367	76,732839	68,1264769	67,64579864	0,480678253	8,675890104	9,087040357
229,6	233,4	88,37	88,29	4300	4069	76,802367	76,732839	68,1365481	67,65857218	0,477975919	8,665818898	9,074266818
229,8	233,6	88,37	88,29	4306	4074	76,802367	76,732839	68,1486181	67,66920242	0,479415683	8,653748899	9,063636582
230,1	233,9	88,38	88,29	4311	4079	76,811058	76,732839	68,15866359	67,67981962	0,478843978	8,652394406	9,053019384
230,3	234,1	88,38	88,3	4317	4085	76,811058	76,74153	68,17070282	67,69254309	0,47815973	8,640355183	9,048986913

230,6	234,4	88,38	88,3	4322	4090	76,811058	76,74153	68,18072273	67,70313171	0,477591016	8,630335272	9,038398288
230,8	234,6	88,38	88,3	4327	4095	76,811058	76,74153	68,19073105	67,7137074	0,477023653	8,620326947	9,0278226
231,1	234,9	88,39	88,3	4333	4101	76,819749	76,74153	68,20272579	67,72638119	0,476344595	8,61702321	9,015148805
231,3	235,1	88,39	88,3	4338	4106	76,819749	76,74153	68,21270872	67,73692853	0,475780189	8,607040277	9,004601466
231,6	235,4	88,39	88,31	4344	4111	76,819749	76,750221	68,22467306	67,74746304	0,477210028	8,595075936	9,002757963
231,8	235,6	88,39	88,31	4349	4117	76,819749	76,750221	68,23463073	67,76008754	0,474543192	8,585118267	8,990133459
232,1	235,9	88,39	88,31	4355	4122	76,819749	76,750221	68,24656483	67,77059391	0,47597092	8,573184166	8,979627086
232,3	236,1	88,39	88,31	4360	4127	76,819749	76,750221	68,25649737	67,78108755	0,475409814	8,563251635	8,969133449
232,6	236,4	88,4	88,31	4366	4133	76,82844	76,750221	68,26840138	67,79366315	0,474738232	8,560038622	8,956557854
232,8	236,6	88,4	88,32	4371	4138	76,82844	76,758912	68,2783089	67,80412887	0,474180027	8,550131101	8,954783129
233,1	236,9	88,4	88,32	4377	4144	76,82844	76,758912	68,29018297	67,81667106	0,473511913	8,538257025	8,942240939
233,3	237,1	88,4	88,32	4382	4149	76,82844	76,758912	68,30006561	67,82710902	0,472956588	8,528374389	8,931802978
233,6	237,4	88,4	88,32	4388	4154	76,82844	76,758912	68,3119099	67,83753441	0,474375488	8,5165301	8,921377588
233,8	237,6	88,41	88,32	4394	4160	76,837131	76,758912	68,323738	67,85002833	0,473709677	8,513392995	8,908883672
234,1	237,9	88,41	88,32	4399	4165	76,837131	76,758912	68,33358243	67,86042617	0,47315626	8,503548573	8,898485833
234,3	238,1	88,41	88,33	4405	4170	76,837131	76,767603	68,34538098	67,87081153	0,474569444	8,491750025	8,896791469
234,6	238,4	88,41	88,33	4410	4176	76,837131	76,767603	68,35520083	67,88325754	0,471943285	8,481930171	8,884345457
234,8	238,6	88,42	88,33	4416	4181	76,845822	76,767603	68,36696997	67,89361557	0,4733544	8,478852033	8,873987432
235,1	238,9	88,42	88,33	4421	4187	76,845822	76,767603	68,37676537	67,90602886	0,470736515	8,469056626	8,861574141

235,3	239,1	88,42	88,33	4427	4192	76,845822	76,767603	68,38850525	67,91635969	0,472145562	8,457316751	8,851243313
235,6	239,4	88,42	88,34	4432	4197	76,845822	76,776294	68,39827633	67,9266782	0,47159813	8,447545669	8,849615799
235,8	239,6	88,42	88,34	4438	4203	76,845822	76,776294	68,40998709	67,9390442	0,470942885	8,435834912	8,837249797
236,1	239,9	88,43	88,34	4443	4208	76,854513	76,776294	68,41973396	67,94933573	0,470398237	8,434779036	8,826958273
236,3	240,1	88,43	88,34	4449	4214	76,854513	76,776294	68,43141575	67,96166943	0,469746321	8,423097253	8,814624574
236,6	240,4	88,43	88,34	4454	4219	76,854513	76,776294	68,44113854	67,9719341	0,469204436	8,413374462	8,804359898
236,8	240,6	88,43	88,35	4460	4224	76,854513	76,784985	68,45279149	67,98218662	0,47060487	8,401721509	8,80279838
237,1	240,9	88,43	88,35	4466	4230	76,854513	76,784985	68,46442878	67,99447363	0,469955142	8,390084223	8,790511366
237,3	241,1	88,44	88,35	4471	4235	76,863204	76,784985	68,47411458	68,00469951	0,469415071	8,389089422	8,780285493
237,6	241,3	88,44	88,35	4476	4241	76,863204	76,784985	68,48378955	68,01695463	0,466834925	8,379414446	8,768030371