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Title:

Preliminary Study of Noise Pollution at Hassi Messaoud / Oued Irara–Krim Belkacem Airport

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بِسْمِ اللَّـهِ الرَّحْمَـٰنِ الرَّحِيمِ

In the name of Allah, the most gracious, the most merciful

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Dedication

To our dear Families

We are infinitely grateful to our family members, particularly our parents for their patience, unwavering support, continuous encouragement, and their belief in us throughout our whole life. We would have never made it this far without them.

Most of that work is for you.

We hope this work brings you happiness.

To all our friends of our class, university, in Algeria, and in the world, may Allah preserve our friendship.

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To all those who have trust us.

Summary

This study conducts a preliminary assessment of noise pollution at Hassi Messoud Airport. It involves measuring noise levels at strategically chosen points using a digital sound level meter with a graphical interface. The aim is to determine the Sound Pressure Levels (SPL) during different flight phases, such as takeoffs and landings, during high-frequency flight periods as communicated by the flight operations department.

The results provide an overview of the noise nuisances and confirm that the noise levels exceed the thresholds set by ICAO for certain flights. These issues need to be addressed with proposed solutions to protect the health of exposed personnel.

ملخص

هذه الدراسة تجري تقييمًا أوليًا للتلوث الضوضائي في مطار حاسي مسعود. تتضمن الدراسة قياس مستويات الضوضاء في نقاط مختارة استراتيجيًا باستخدام جهاز قياس مستوى الصوت الرقمي بواجهة رسومية. الهدف هو تحديد مستويات ضغط الصوت خلال مختلف مراحل الطيران، مثل الإقلاع والهبوط، خلال فترات الطيران ذات التردد العالي كما تم التواصل بها من قبل قسم العمليات الجوية

النتائج تقدم نظرة عامة على الإزعاجات الضوضائية وتؤكد أن مستويات الضوضاء تتجاوز الحدود التي وضعتها منظمة الطيران المدني الدولي لبعض الرحلات الجوية. يجب معالجة هذه المشكلات من خلال اقتراح حلول لحماية صحة الأفراد المعرضين لهذه المستويات من الضوضاء

Résumé

Cette étude effectue une évaluation préliminaire de la pollution sonore à l'aéroport de Hassi Messaoud. Elle consiste à mesurer les niveaux de bruit à des points choisis stratégiquement à l'aide d'un sonomètre numérique avec interface graphique. L'objectif est de déterminer les niveaux de pression acoustique (SPL) pendant les différentes phases de vol, telles que les décollages et les atterrissages, pendant les périodes de vol à haute fréquence, telles que communiquées par le département des opérations de vol.

Les résultats fournissent un aperçu des nuisances sonores et confirment que les niveaux de bruit dépassent les seuils établis par l'OACI pour certains vols. Ces problèmes doivent être abordés avec des solutions proposées pour protéger la santé du personnel exposé.

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List of abbreviations

db:	decibel
db(A):	A-weighted decibels
db(C):	C-weighted decibels
db(Z):	Unweighted decibels
EPNdB:	Effective Perceived Nose Decibel
EPNL:	Effective Perceived Noise Level
LDEN:	Day-Evening-Night Level
NAx:	Noise events Above x dB(A)
Leq:	Equivalent Continuous Sound Level
LAeq:	A-Weighted Equivalent Continuous Sound Level
L den:	The weighted indicator (day-evening-night)
LAmax:	maximum instantaneous level
SEL:	sound exposure level
ICAO:	International Civil Aviation Organization
PEB:	Noise Exposure Plans
PLUs:	Local Urban Plans
ACNUSA:	Airport Nuisances Control Authority
PGS:	The Noise Disturbance Plan
ECAC:	European Civil Aviation Conference
DGAC:	Directorate General for Civil Aviation
INM:	Intelligent Network Management
FAA:	Federal Aviation Administration
ANP:	Aircraft Noise and Performance
APU:	Auxiliaries Power Unit
WHO:	World Health Organization

General Introduction

Airplane noise has the potential to adversely affect human well-being. This issue has led to a significant number of individuals experiencing hearing loss, making it a prominent factor in this condition. With population growth and the expansion of airports, both residents and workers are increasingly subjected to noise pollution from airports and nearby structures. Consequently, it is imperative to address this issue by incorporating additional sound insulation measures in buildings to mitigate the impact of noise pollution. Those most affected by airport noise are residents near the airport and individuals who work in or around the airport. Therefore, various regulations and programs have been implemented in countries to reduce the impact of this pollution. High levels of airplane noise near major airports are also known to increase blood pressure in addition to causing hearing loss.

Hassi Messaoud Airport, a crucial hub for Algeria's oil and gas industry, experiences high air traffic, particularly from cargo and charter flights. While this traffic is essential for the region's economic activities, it contributes to significant levels of noise pollution, impacting both the airport's operational environment and the surrounding communities. As noise pollution becomes an increasingly important public health and environmental concern, understanding and managing noise at such critical infrastructure is vital.

This project aims to analyze the sources, levels, and impacts of noise at Hassi Messaoud Airport. By examining factors such as aircraft operations, ground support activities, and the proximity of residential areas, the study seeks to provide a comprehensive assessment of noise pollution in this context. Additionally, the project will explore current noise mitigation strategies employed at the airport and evaluate their effectiveness, offering recommendations for potential improvements.

Through this investigation, the study intends to contribute to ongoing efforts to balance the operational demands of Hassi Messaoud Airport with the need for environmental sustainability and community well-being. The following sections will detail the scope of the project, review relevant research, and outline the methodologies used in this analysis

Chapter 1: Generalities of Noise

1.1. Definitions

1.1.1 Sound:

The sound is an elastic disturbance of the elements of the medium in which it propagates, this medium being a gas (air), a liquid, or a solid. A pure sound can be characterized by its intensity (its strength) and its frequency (low or high).

1.1.2 Noise:

Noise is a group of sounds without harmony. For aircraft in flight, we distinguish between power unit noise, which dominates during the takeoff phase, and aerodynamic noise which becomes as important as engine noise during the landing phase. For example, when an aircraft lands, the noise perceived is not the engine noise but is essentially the noise of the airflow along the aircraft's cabin.

1.1.3 Acoustics:

The branch of science concerned with the study of sounds related to aircraft and the aviation environment. It covers many different aspects of sound generation, propagation, measurement and its effects on the aircraft, passengers, crew and the environment. Acoustics in aviation involves understanding how aircraft make noise, how sound waves travel through the air and interact with aircraft and airport infrastructure, and how noise affects individuals and the community inside and outside the aircraft. Acoustic principles are applied in the design and development of quieter aircraft, the assessment and management of noise pollution around airports, and the implementation of noise reduction strategies to improve the overall aviation experience. possible and minimize impact on the environment.

1.1.4 Noise Pollution:

Noise pollution refers to the excessive and disruptive noise caused by human activities that disrupt the natural balance of sound in the environment. This type of pollution typically stems

from industrial activities, transportation systems (such as traffic and aircraft), construction sites, loud events, and everyday activities like loud music or noisy appliances.

1.2 The Physical Characteristics of Noise:

The physical characteristics of noise in the context of aeronautics involve various aspects related to the generation, propagation, and perception of sound produced by aircraft. Here are some key physical characteristics:

1.2.1 Sound Level (Decibel Level):

Aircraft noise is typically measured in decibels (dB). The sound level of aircraft noise can vary depending on factors such as the type of aircraft, its engines, the phase of flight (takeoff, landing, cruising), and the distance from the source.

1.2.2 Temporal Patterns:

Aircraft noise may exhibit temporal patterns, such as intermittent bursts during takeoff and landing or continuous noise during cruising. These patterns can affect how noise is perceived by individuals and communities.

1.2.3 Frequency:

Spectrum: Aircraft noise consists of a range of frequencies, spanning from low-frequency rumbling to high-frequency whining. Different components of aircraft, such as engines, aerodynamics, and auxiliary systems, contribute to different frequency bands in the noise spectrum.

We talk about bass (low frequencies) or treble (high frequencies). The range of audible sounds extends from 20 Hz to 20,000 Hz or from 20 vibrations per second to 20,000. Below 20 Hz we talk about infrasound (e.g. wind turbines) and above infrasound.

1.2.4 Amplitude:

The ear does not hear noises of all frequencies in the same way and tends to attenuate low-frequency noises. To take this phenomenon into account, devices (noise meters) have an electronic circuit allowing for the attenuation of these low-frequency noises. When measuring noise, not as it exists, but as it is heard, we refer to it in dB(A). The decibel scale is difficult to use

(it is logarithmic), so if two identical noises, for example, 60 dB(A), occur simultaneously, the total is not 120 dB(A) but only 63 dB(A). Doubling the sound intensity therefore corresponds to

Conversation	Auditory Sensation	Level Sound dB(A)	Human Reaction	Examples
whispered voice	Very calm	0 to 30	a sense of deep calmness	a low voice conversation
Normal voice	Fairly quiet	50	the beginning of disturbance	moderate rain, washing machine
raised voice	Noisy but bearable	70	disruptive when on the telephone	busy street, vacuum cleaner
Very loud voice	Hard	85	difficult to have a conversation	alarm clock, factory, noisy restaurant
Shouted voice	Unbearable	90	a feeling of heavy noise	subway, lawnmower, alarm
Extreme voice	Intolerable	100	bearable for a short period of time; maximum vocal effort to be heard	drill, chainsaw, motorcycle
Impossible	Pain threshold	120	beginning of pain	loud concert, club

Table 1 Noise sources and human responses by level

1.2.5 Directionality:

Aircraft noise can be directional, with noise levels varying depending on the observer's position relative to the aircraft's flight path and engine orientation. This means that people located directly under a flight path may experience higher noise levels compared to those located to the side.

1.2.6 Duration:

The duration of aircraft noise events can vary, ranging from short bursts during takeoff and landing to continuous noise during taxiing and engine testing. The duration of noise events can influence their impact on individuals and communities.

1.2.7 Propagation:

The propagation of aircraft noise through the atmosphere is influenced by factors such as atmospheric conditions, temperature gradients, wind speed, and the presence of obstacles or terrain. These factors affect how far the noise travels and how it attenuates with distance.

1.2.8 Ground Reflections and Absorption:

The airport environment, including buildings, terrain, and vegetation, can affect the reflection, absorption, and dispersion of aircraft noise. Hard surfaces like concrete runways and buildings can reflect noise, while soft surfaces like grass or trees can absorb it.

1.2.9 Speed of Propagation:

It is 340m/s. When sound reflects off obstacles (walls, trees, etc.) it is called an "echo." That is, the sound will sound more muffled, but there will be no change. When it reflects off the walls, floor, and ceiling of a room, it is called reverberation. This means that the original sound is no longer recognizable. The noise just continues and gradually fades away.

Understanding these physical characteristics of aircraft noise is essential for assessing its impact on individuals and communities, designing effective noise mitigation strategies, and developing quieter aircraft and airport operations.

1.3. Effects of Noise Pollution:

When discussing the effects of noise pollution, it's essential to consider its impacts on both human health and the environment. Here's a detailed exploration of these effects:

1.3.1. Effects on Human Health:

1.3.1.1 Hearing Loss*:*

Prolonged exposure to high levels of noise can cause temporary or permanent hearing impairment. This is particularly common in industrial workers, musicians, and individuals living in noisy urban areas.

1.3.1.2 Sleep Disturbance*:*

Noise pollution disrupts sleep patterns, leading to insomnia and sleep deprivation. Even low-level noise can disturb sleep, resulting in fatigue, irritability, and decreased cognitive function.

1.3.1.3 Stress and Anxiety*:*

Continuous exposure to noise triggers the body's stress response, leading to increased levels of cortisol and adrenaline. Chronic stress from noise pollution can contribute to anxiety, hypertension, and other psychological disorders.

1.3.1.4 Cardiovascular Effects:

Studies have linked noise pollution to elevated blood pressure, heart disease, and stroke. Exposure to loud noise over time can increase the risk of cardiovascular problems, including hypertension and heart attacks.

1.3.1.5 Cognitive Impairment*:*

Noise pollution impairs concentration, memory, and cognitive performance. Children exposed to noise pollution may experience delays in language development and academic achievement due to difficulty concentrating in noisy environments.

1.3.1.6 Interference with Communication:

Excessive noise makes it challenging to communicate effectively, leading to misunderstandings and social isolation. Individuals with hearing impairments are particularly vulnerable to communication difficulties in noisy environments.

1.3.2. Effects on the Environment:

1.3.2.1 Impact on Wildlife:

Noise pollution disrupts natural habitats and wildlife behavior. Loud noises from human activities, such as construction, traffic, and industrial operations, interfere with animal communication, navigation, and mating calls, leading to changes in species distribution and reproductive patterns.

1.3.2.2 Ecological Disruption:

Noise pollution alters ecosystem dynamics by affecting species interactions, predator-prey relationships, and community structure. Some animals may abandon their habitats or alter their behavior to avoid noisy areas, leading to shifts in biodiversity and ecosystem function.

1.3.2.3 Habitat Degradation:

Noise pollution can degrade natural habitats, especially in sensitive ecosystems such as marine environments and wilderness areas. Anthropogenic noise from sources like shipping, offshore drilling, and recreational boating disrupts marine life, including marine mammals, fish, and invertebrates.

1.3.2.4 Physiological Effects:

Wildlife exposed to chronic noise stress may experience physiological changes, including elevated stress hormone levels, decreased reproductive success, and compromised immune function. These effects can have long-term consequences for individual fitness and population viability.

I.4.Measurement Units of Noise:

Noise is often measured in units such as decibels (dB). Decibels measure the intensity or level of sound. There are also different weighted scales used to measure noise depending on the context.

1.4.1 The decibel (dB):

The decibel (dB) is the unit chosen for sound level. This unit has the advantage of closely matching the differential sensitivity of hearing, since a difference of 1 decibel between 2 noise levels corresponds closely to the smallest difference in sound level detectable by the human ear.

1.4.2 The decibel dB(A):

A-weighted decibels, which are adjusted to approximate the sensitivity of the human ear to different frequencies.

1.4.3 The decibel dB(C):

C-weighted decibels, which emphasize low-frequency sounds more than A-weighting.

1.4.4 The decibel dB(Z):

Unweighted decibels, which do not apply any frequency weighting.

1.4.5 Effective Perceived Nose Decibel (EPNdB):

Effective perceived noise in decibels (EPNdB) or Effective Perceived Noise Level (EPNL) is a measure of the relative noisiness of an individual aircraft pass-by event. It is used for aircraft noise certification and applies to an individual aircraft, not the noise exposure from an airport.

1.4.6 LDEN:

LDEN stands for "Day-Evening-Night Level" and is a weighted noise indicator used in environmental noise assessment. It represents the average noise level over a 24-hour period, with separate weightings for daytime, evening, and nighttime hours. LDEN is often used in studies related to community noise exposure and its potential effects on human health and well-being.

1.4.7 NAx:

"Noise events Above x dB(A)" refers to instances of noise that exceed a specific threshold level measured in decibels using the A-weighting scale. This terminology is commonly used in contexts where monitoring and regulating noise pollution are important, such as in environmental studies, urban planning, workplace safety, or community noise ordinances.

1.5. Acoustic indicators:

Acoustic indicators refer to measurements or metrics used to quantify and evaluate acoustic properties or phenomena. These indicators can include parameters such as sound pressure level, frequency spectrum, reverberation time, and others, which are used to assess aspects of sound in various environments such as industrial settings, urban areas, or natural habitats.

1.5.1. Energy indicators:

1.5.1.1. Equivalent Acoustic Levels

The "equivalent acoustic level" (Leq, t expressed in dB) of a stable or fluctuating noise is equivalent, from an energetic point of view, to a permanent and continuous noise that would have been observed at the same measurement point and during the same period. The equivalent acoustic level therefore corresponds to a "noise dose" received over a determined period of time.

It is the result of calculating the integral of the sound levels recorded at regular intervals (sampling every 1, 2... n times per second) and for a given period, t (10 minutes, 1 hour, 24 hours, ...). If the sampling was performed with frequency weighting (A for example), the equivalent level will then be expressed in dB(A) and symbolized by LAeq, t.

This level is very regularly used as an annoyance indicator. Indeed, in practice, there is a good correlation between this value and the auditory annoyance felt by an individual exposed to the noise. However, the LAeq, t indicator smooths out the short-duration amplitude peaks observed during the considered period. This is why other "event-based" indicators are also used.

1.5.1.2. Fractal Levels*:*

The "fractal level" is expressed in dB and is symbolized by the parameter Lx, where x is between 0 and 100 (for example: L10). It expresses the sound level exceeded during the percentage of time x (10%, 95%, ...) compared to the total duration of the measurement.

Like equivalent levels, fractal levels are determined based on sound levels recorded at regular intervals (sampling) and for a given period. The statistical analysis involves classifying all the samples collected according to their level and calculating the duration, expressed in %, during which a given noise level was exceeded. The values L1 and L5 generally characterize peak levels and allow for taking into account the strong emergence characteristic of certain noises, while the values L90 and L95 characterize background noise levels.

If the sampling was performed with weighting (A for example), the fractal levels will then be expressed in dB(A) and symbolized by LAx.

1.5.1.3. Global annoyance indicators defined by the "noise directive"

At the European level, Directive 2002/49/EC on the assessment and management of environmental noise has defined various global indicators, in particular:

1.5.1.3.1 L Day:

L day corresponds to the representative average noise level of a day (LAeq (7am-7pm)), determined over a year. It constitutes an indicator of noise associated with annoyance during the daytime.

1.5.1.3.2 L evening:

L evening corresponds to the representative average noise level of an evening (LAeq (7pm-11pm)), determined over a year. It constitutes an indicator of noise associated with annoyance in the evening.

1.5.1.3.3 L night:

L night corresponds to the representative average noise level of a night (LAeq (11pm-7am)). It constitutes an indicator of noise associated with sleep disturbances.

1.5.1.3.4 L den:

The weighted indicator L den (day-evening-night) represents the average annual level over 24 hours, evaluated from the average daytime (7am-7pm), evening (7pm-11pm), and night (11pm-7am) levels. In its calculation, the average evening and night levels are increased by 5 and 10 dB(A) respectively. In other words, this noise indicator is associated with overall acoustic annoyance related to long-term noise exposure and takes into account that noise experienced in the evening and during the night is felt as more annoying. It is used notably for the establishment of strategic noise maps. It is calculated according to the formula:

$$LDEN=10*\log 1/24 *[\ 12*10^{\frac{LAeq,7-19}{10}} + 4*10^{\frac{(LAeq,19-23)+5}{10}} + 8*10^{\frac{(LAeq,23-7)+10}{10}}\ ]$$

1.5.2. Event-based indicators

Among the event-based indicators, the following indicators can be mentioned:

1.5.2.1 LAmax or "maximum instantaneous level":

LAmax is the maximum noise level measured (with A-weighting) during a given period of time. It corresponds to a sound level that is never exceeded and is therefore equal to the fractal level LA0.

1.5.2.2 SEL:

SEL (or LEA) is the sound exposure level. It integrates both the noise level and the duration during which the noise is present. SEL is defined as the level constant for one second having the same acoustic energy as the original sound perceived over a given duration. This acoustic indicator is often used to quantify the sound energy of a single event (such as the passage of a vehicle) and to compare the sound events from the same source. SEL is calculated according to the formula:

$$SEL= LAeq,\ t + 10 * \log(t)$$

With t = duration of the event expressed in seconds

1.5.3 Sources of Noise Pollution [2]:

There are many sources of noise pollution, but here are some of the main ones:

1.5.3.1 Traffic noise*:*

Traffic noise accounts for most polluting noise in cities. For example, a car horn produces 90 dB and a bus produces 100 db.

1.5.3.2 Air traffic noise*:*

There are fewer aircraft flying over cities than there are cars on the roads, but the impact is greater: a single aircraft produces 130 db.

1.5.3.3 Aircraft noise*:*

- Engine Noise
  - In the propulsion group, it includes:

- Jet noise,

- Noise from rotating parts of the engine (upstream and downstream blowers, compressor, and turbine),

- Combustion noise, and internal noises.

Jet noise is due to the generation of strong turbulence in the area where the hot, high-pressure gases ejected from the engine nozzle mix with the surrounding air.

- In turbojet engines, it includes:

Jet noise, noise from rotating parts consisting of the fan, compressors, and turbines.

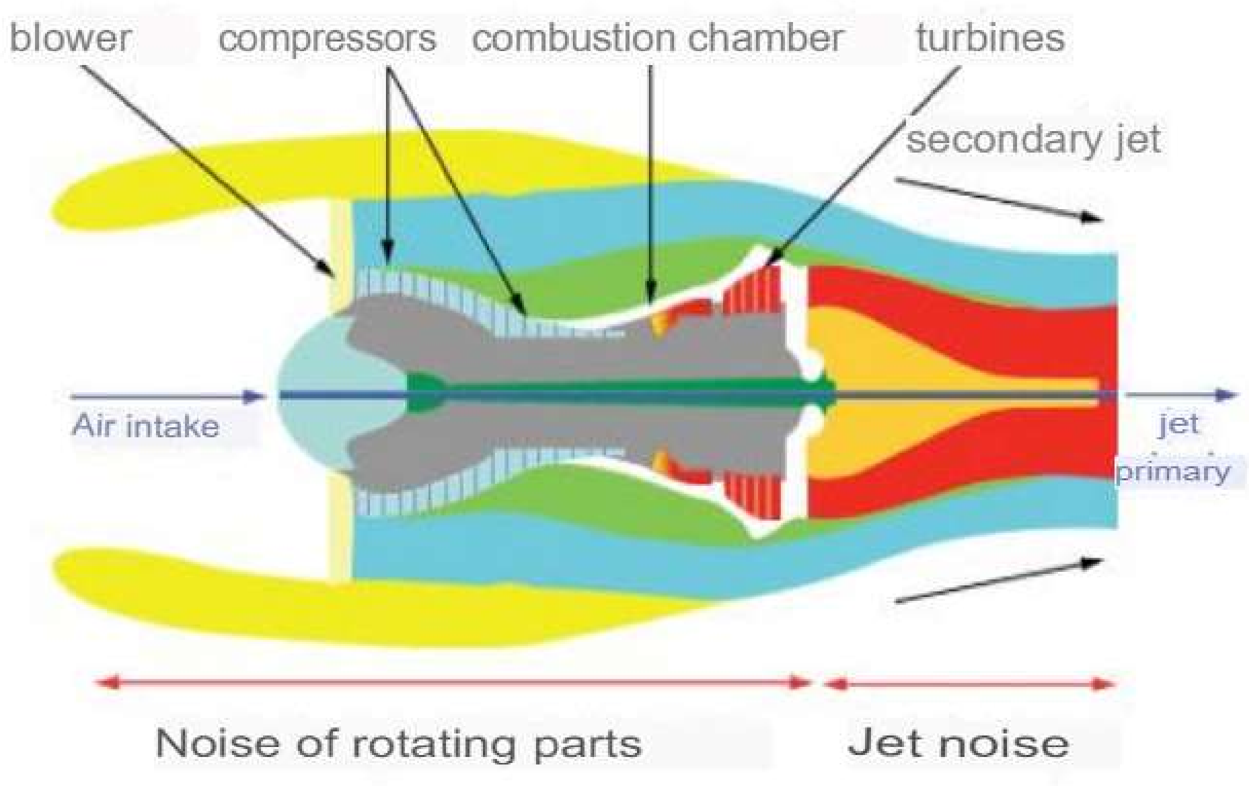

Figure 1-1: the noise of the power plants

- **Aerodynamic Noise:**

Aerodynamic noise is due to aerodynamic turbulence created around the aircraft. The noise from the flaps, slats, and landing gear are examples of this.

Given the progress made on engines, this source of noise becomes as important, or even more significant than engine noise during landing phases with extensive flap deployment.

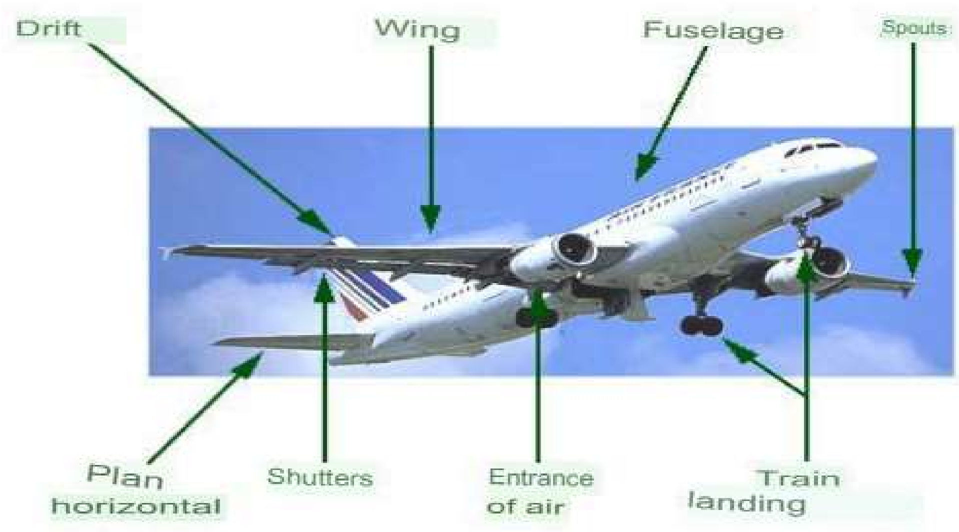

Figure 1-2: The main elements contributing to airborne noise

The noise produced by aircraft during their parking (engine tests) or taxiing on the ground can also be a source of noise nuisance for airport neighbors.

Helicopter noise, on the other hand, has three origins: the noise from the main rotor, the noise from the tail rotor, and engine noise.

- **Construction sites:**

Building and car park construction and road and pavement resurfacing works are very noisy. For example, a pneumatic drill produces 110 dB.

- **Catering and night life:**

Restaurants and terraces that spill outside when the weather is good can produce more than 100 dB. This includes noise from pubs and clubs.

- **Animals:**

Noise made by animals can go unnoticed, but a howling or barking dog, for example, can produce around 60-80 dB.

1.6. Effects of noise pollution: [10]

As well as damaging our hearing by causing — tinnitus or deafness —, constant loud noise can damage human health in many ways, particularly in the very young and the very old. Here are some of the main ones:

1.6.1 Physical:

Respiratory agitation, racing pulse, high blood pressure, headaches and, in case of extremely loud, constant noise, gastritis, colitis and even heart attacks.

1.6.2 Psychological:

Noise can cause attacks of stress, fatigue, depression, anxiety and hysteria in both humans and animals.

1.6.3 Sleep and behavioral disorders:

Noise above 45 dB stops you from falling asleep or sleeping properly. Remember that according to the World Health Organization it should be no more than 30 db. Loud noise can have latent effects on our behavior, causing aggressive behavior and irritability.

1.6.4 Memory and concentration:

Noise may affect people's ability to focus, which can lead to low performance over time. It is also bad for the memory, making it hard to study.

Interestingly, our ears need more than 16 hours' rest to make up for two hours of exposure to 100 db.

1.7 International Acoustic Regulation:

Aircraft noise remains one of the most keenly felt noise nuisances by the population. States and airports have been concerned with limiting it through regulatory means.

International standards have been required to minimize noise nuisances. These standards are defined by the International Civil Aviation Organization in a document entitled Annex 16 "Environmental Protection Volume I Aircraft Noise."

Despite the increase in air traffic worldwide, this regulation aims to reduce aircraft noise. For this reason, ICAO encourages aircraft manufacturers and operators to use the most effective noise reduction technologies, compatible with safety and economic reliability imperatives.

❖ **Aircraft Acoustic Certification:**

Before being put into operation, each aircraft/engine combination undergoes very precise measurements of its various noise levels in the 3 phases of flight: takeoff at full power, approach, and overflight. This is the subject of acoustic certification regulated by ICAO.

The basic unit for the certification of jet aircraft is the EPNDB, which is characterized by a strong weighting of medium to high frequencies that are highly annoyance-generating.

For subsonic jet aircraft, which constitute the main source of noise nuisances near airports, regulations were established in the early 1970s and before October 6, 1977, and stated in Chapter 2 of ICAO Annex 16, defining maximum noise levels based on different aircraft categories and takeoff mass.

This evolution leads to classifying jet transport aircraft into three generations, each representing a decrease of at least 50% in acoustic energy level compared to the previous one:

- Jet aircraft certified before October 6, 1977, according to Chapter 01 of ICAO Annex 16.

- Jet aircraft certified between 1970 and before October 6, 1977, according to Chapter 02 of ICAO Annex 16.

- Jet aircraft certified between October 6, 1977, or a later date, and before January 1, 2006, according to Chapter 03 of ICAO Annex 16.

1.8. Noise Exposure Plans (PEB):

Law No. 85-696 of July 11, 1985, concerning urban planning in the vicinity of aerodromes, established Noise Exposure Plans (PEB), the purpose of which is to allow controlled development of neighboring municipalities without exposing new populations to the noise generated in certain areas by airport operations.

The aim is to protect airports from rapid urbanization, particularly to prevent new populations from settling near an airport.

1.8.1. Definition:

Noise Exposure Plans (PEB) delineate zones (A, B, and C) within which urban planning requirements are defined (up to the prohibition of construction in the most exposed zones), taking into account traffic assumptions (over ten to fifteen years). As such, PEBs must be appended to the PLUs (Local Urban Plans) of the concerned municipalities and are opposable to any construction request. The law of July 12, 1999, opened the possibility of endowing PEBs with a fourth zone, known as zone D. In this zone, constructions are allowed provided they comply with specific insulation standards (defining a zone D is mandatory for the 9 main airports and optional for other platforms).

It is the responsibility of elected officials to ensure that PEBs are as extensive as possible, defended, and respected (constructions built in rural areas today find themselves in the situation we know). Based on the recommendations of ACNUSA, a new decree signed in April 2001 modified the rules for establishing these plans. All current PEBs must be revised according to these new rules by December 31, 2005. The use of a new planning index, the Lden in accordance with European recommendations, as well as the choice of values adapted to this index, will lead to a substantial expansion of PEB zones.

1.8.2. Standard Layout of a Noise Exposure Plan:

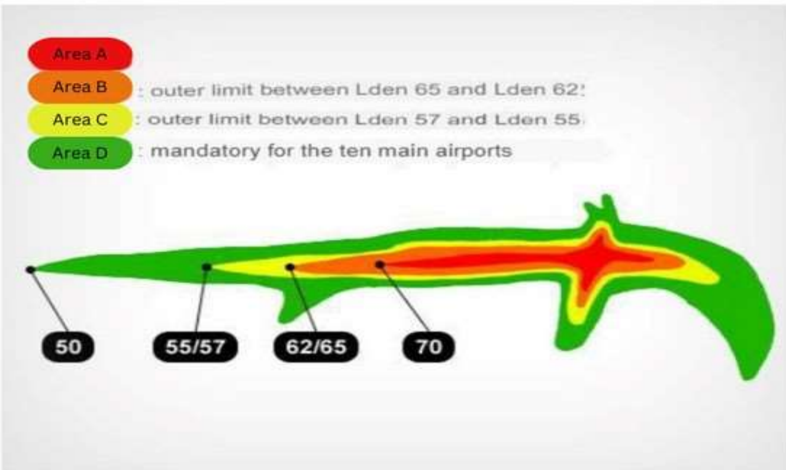

Figure 1-3: Standards Layout of Noise Exposure Plan

The importance of exposure is indicated by the letters A, B, C, or D.

Zone A : Very high noise exposure.

Zone B : High noise exposure.

Zone C : Moderate noise exposure.

Zone D : Low noise exposure.

1.9. The Noise Disturbance Plan (PGS)

While the Noise Exposure Plan (PEB) is a tool for urban planning control (over a period of 10 or 15 years), the PGS (established by Law No. 92-1444 of December 31, 1992) is a tool allowing short-term assistance to airport residents in terms of soundproofing homes. The PGS defines areas - outside the PEB - within which residents can request assistance.

It takes the form of a report and a map at a scale of 1/25,000 indicating 3 types of zones:

- Zone 1, known as very high nuisance, located within the Lden 70 index curve.

- Zone 2, known as high nuisance, between the Lden 70 and Lden 65 or 62 index curves.

- Zone 3, known as moderate nuisance, included between the outer limit of Z2 and Lden 55.

1.10. Method of Noise Map Development

Modeling aircraft noise around airports relies on three components:

- ✓ A noise calculation method implemented in computer software;
- ✓ An aircraft database necessary to finely characterize the sound emissions of each aircraft;
- ✓ Data related to infrastructure, traffic, trajectories, and operating conditions specific to each airport.

The noise calculation method and the aircraft database are harmonized internationally and used in the same manner regardless of the type of noise map and the size of the airport being studied. The reference documents in this matter are ICAO Doc 9911 and ECAC Doc 29, 3rd edition. This international technical framework should also be officially recognized by community authorities as part of the next revision of Directive 2002/4913.

This internationally harmonized method was initially developed for calculating noise contours around civil airports, with helicopters and military aviation not included in the original scope of

Doc 29 and Doc 9911. However, in the absence of other specific operational methodologies defined internationally, the DGAC has chosen to use the same software tools for all airports regardless of traffic typology.

Aircraft noise on the ground (taxiing, engine tests, APU), which is usually not dominant compared to noise generated during landing and takeoff phases, is not addressed in this method. Conversely, all flight phases on the runway (including power-up before takeoff and thrust reverser activation on landing) are well covered by the noise modeling method described below.

✓ **The Calculation Engine:**

The calculation method defined at the international level does not refer to a specific software tool. For the noise maps under its responsibility, the DGAC has chosen to use the INM software developed by the United States Federal Aviation Administration (FAA) and compatible with the calculation method harmonized at the ICAO and ECAC levels.

As of current knowledge, the so-called "segmentation" method - an intermediate method between simple models (calculating the shortest distance to the flight trajectory) and integral simulations - is the best compromise in terms of cost/effectiveness/feasibility/precision for calculating noise contours around airports.

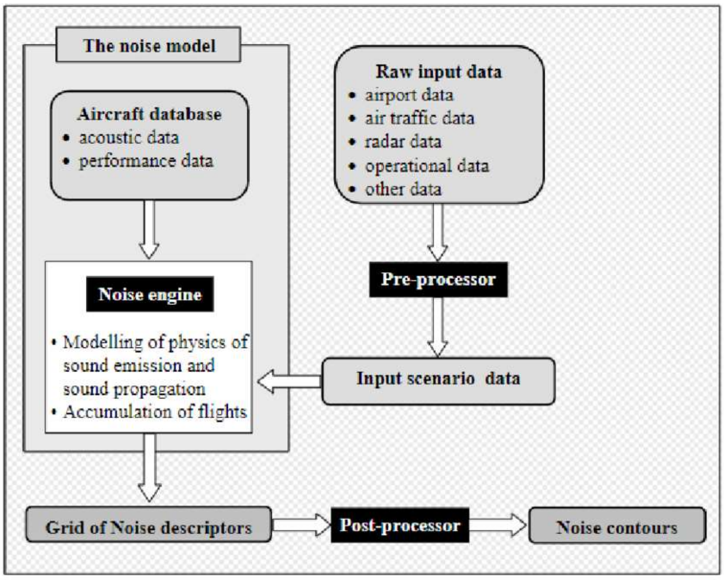

Figure 1-4: Flowchart of the aircraft noise model

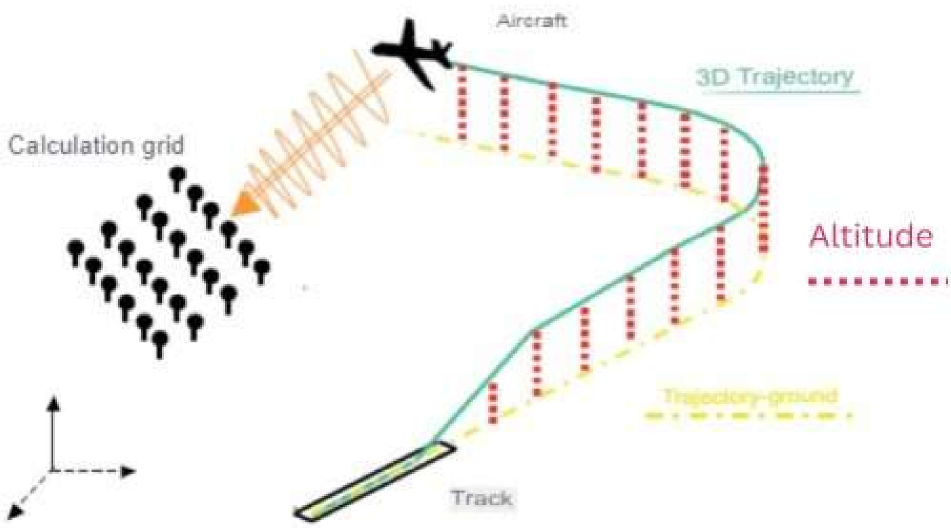

Figure 1-5: Noise model

The segmentation method first involves dividing an aircraft's trajectory into several segments and assessing the contribution of each segment to the noise exposure level induced by the aircraft's passage based on:

- ✓ The source-receiver distance from the ground,
- ✓ Specific acoustic and performance data for each aircraft (data from ANP),
- ✓ The lateral directivity of the source induced by engine installation effects,
- ✓ Lateral noise attenuation (ground effect).

The "noise fractions" of significant segments (those that contribute significantly to the noise level generated by the aircraft's passage) are then summed.

The noise module calculates noise levels at discrete points on a predefined calculation grid. These values are the input data for a post-processor that generates isophonic curves.

The value of the Lden (or Ln) index is finally obtained by energy summation of the sound levels calculated for each aircraft passage, applying predefined weightings for the three day/evening/night periods (exclusively for Lden).

The method for calculating sound levels induced by each aircraft passage is described in detail in Volume 2 of ECAC Document 29 and in ICAO Doc 9911.

Chapter 2: Noise Pollution at the Level of the Airport

2.1 Environmental impacts of airports

Aviation in the twenty-first century contributes to climate change, noise and air pollution. Together with various social and economic problems, environmental issues have the potential to constrain the operation and growth of airports. Constraints on airport capacity affect the capacity of the air navigation system as a whole. Many international airports are operating at their maximum, and some have already reached their operating limits including those resulting from environmental impact. This situation is expected to become more widespread as air traffic continues to increase. Already aircraft noise is a limiting factor for the capacity of regional and international airports throughout the world.

There are many definitions of airport capacity with regard to various issues: operational, flight safety, economic and environmental. The relative importance of each issue depends on the local, regional and national circumstances of each airport (see Figure 2-1). Environmental capacity is the extent to which the environment is able to receive, tolerate, assimilate or process the outputs of aviation activity. Local environmental airport capacity can be expressed in terms of the maximum numbers of aircraft, passengers and freight accommodated during a given period under a particular environmental limitation and consistent with flight safety. For example, the airport noise capacity is the maximum numbers of aircraft that can be operated during a given period so that total aircraft noise levels do not exceed a prescribed limitation in critical zones around an airport.

Aircraft noise is noise associated with the operation and growth of airports that impact upon local communities, in particular the nature and extent of noise exposure arising from aircraft operations. It is the single most significant contemporary environmental constraint, and is likely to become more severe in the future.

Local air quality is a capacity issue at some European airports, and is likely to become more widespread in the short to medium term. After aircraft noise, local air quality seems to be the next most significant environmental factor with the potential to constrain airport growth

Third party risk is a potential future constraint for certain larger airports located close to built-up areas. The communities surrounding such airports are exposed to the small risk of an aircraft crash. {5}

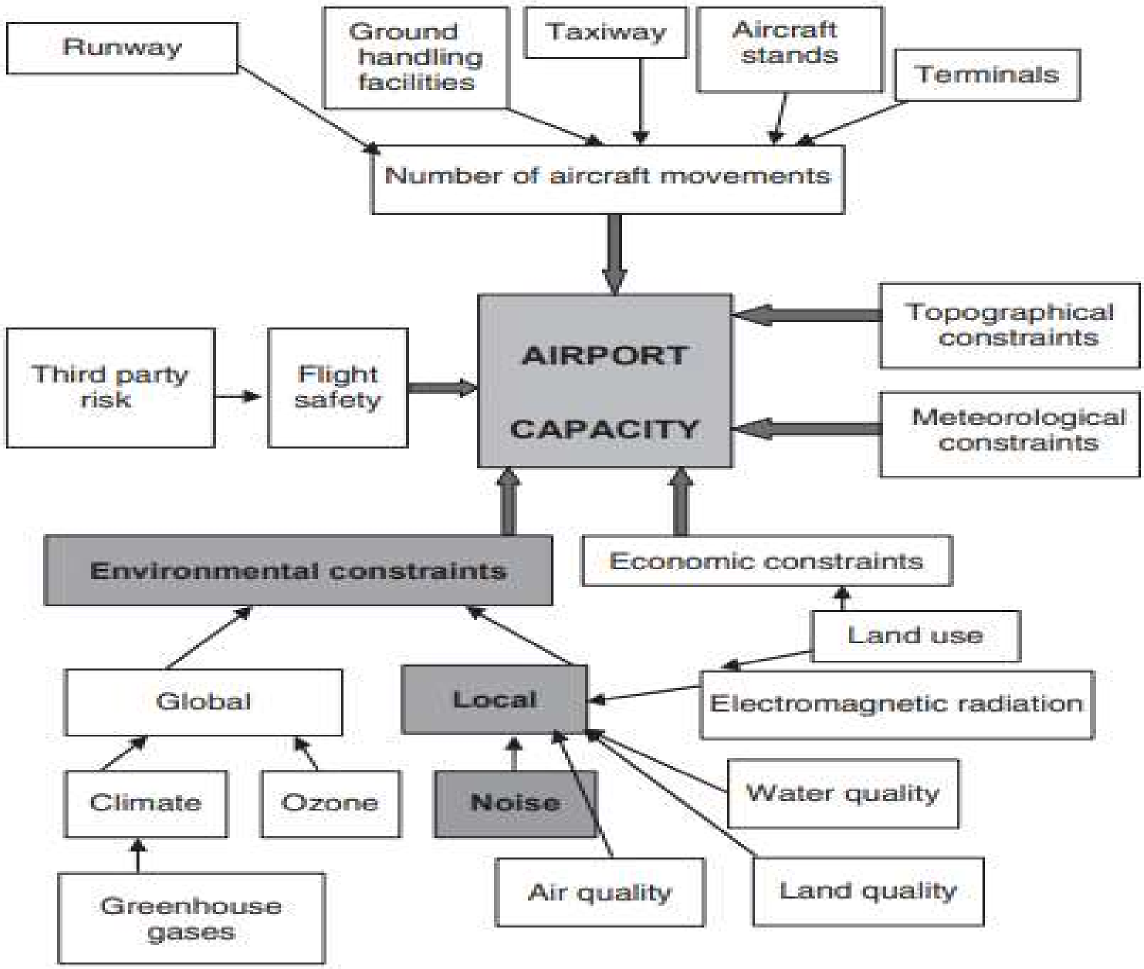

Figure 2-1: Environmental influences on airport capacity

2.2 Description of aircraft noise {5}

Aircraft are complex noise sources (see Figure 2-2). So, a variety of noise protection methods are employed around airports; including organizational, technical, operational and zoning methods. The main noise sources on an aircraft in flight are the power unit and the aerodynamic noise. Aerodynamic noise becomes particularly noticeable during the landing approach of heavy jet aircraft, when the engines are at comparatively low thrust. The scientific basis for abating noise from aircraft relies on advances that have been made in aeroacoustics. Unlike classical acoustics (which is concerned mainly with the sound caused by oscillating surfaces), aeroacoustics investigates aerodynamic noise conditioned by turbulent non-stationary flow.

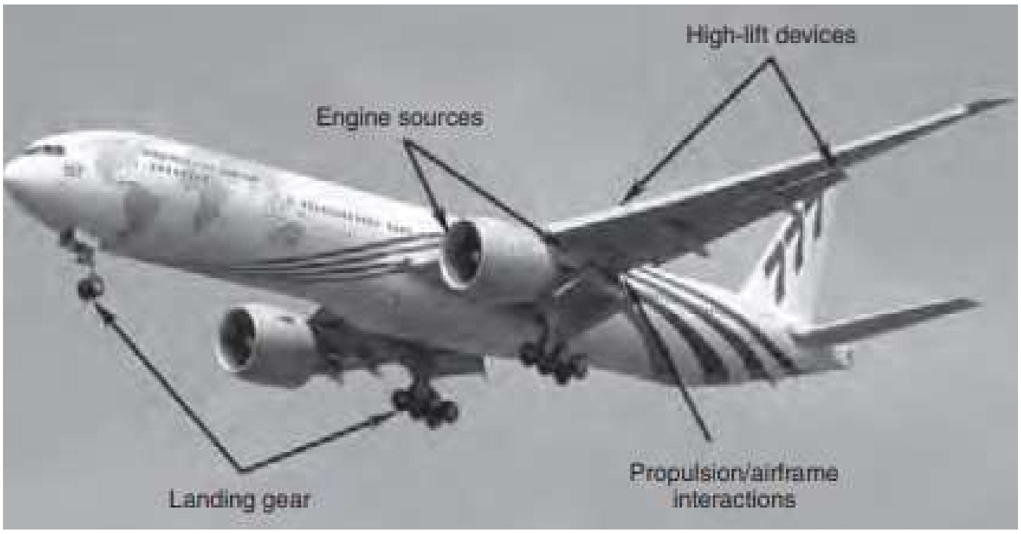

Figure 2-2: Aircraft noise sources

Typically, jet aircraft noise sources include : jet noise, core noise, inlet and aft fan noise, turbine noise and airframe noise. Figure 7 shows a classification of aircraft noise sources.

Aircraft class		*Main sources of noise*	
		Power-unit	*Airframe*
Aircraft – ordinary takeoff and landing	Turbojet	Jet, fan, core noise	Flap and wing trailing edges, flap side edges, slats, gear sources, fuselage and wing turbulent boundary layers
	Turboprop	Propeller, propfan, engine exhaust	
Aircraft – short takeoff and landing	Turbojet	Fan, engine exhaust	Interaction jet with flap
	Turboprop	Propeller	
Supersonic aircraft		Jet	Interaction of flow with frame
Helicopters		Blades of main rotor, engine exhaust	Not important
Aircraft of general aviation	Turbojet	Jet, fan	Not important
	Turboprop	Propeller, engine exhaust	

Figure 2-3: A classification of noise sources on aircraft

2.3 Aircraft noise pollution:

Airplane noise refers to the noise emitted by an airplane in flight, which has been linked to a number of negative health effects from stress, from sleep problems to heart disease. The authorities have introduced important powers that apply to aircraft designers, manufacturers and operators, which will improve conditions and reduce pollution.

2.4 Mechanisms of sound production:

Aircraft noise is any noise produced by an aircraft or its components, whether on the ground during an auxiliary engine, during taxi, or during coming out of the propeller and the jet tube, during take-off, when approaching the departure and arrival routes, too much. in route or during landing. A moving airplane, or even a jet engine, compresses and thins the air, causing the air molecules to move. This movement is propagated in the form of pressure waves in the atmosphere. If these pressure waves are strong enough, they are in the audible frequency range and cause hearing loss. Different types of aircraft have different noise levels and frequencies. There are three main sources:

- Engine and different mechanical noise
- Aerodynamic noise
- Noise from aircraft systems

2.4.1 Engine and different mechanical noise: [3]

Much of the noise in propeller aircraft comes from the propeller and aerodynamics as well. Helicopter noise is aerodynamically induced noise from the main and tail rotors, as well as mechanically induced noise from the main gearbox and various transmission chains. Mechanical sources produce narrow band peaks of high intensity related to rotational speed and movement of moving parts. From a computer modeling perspective, the noise of a moving aircraft can be treated as a line source.

Aircraft gas turbine engines (jet engines) are responsible for much of the aircraft noise during takeoff and climb. For example, the buzzsaw noise that occurs when the tips of fan blades reach supersonic speeds. However, due to advances in noise reduction technology, aircraft tend to be noisier during landing. [citation needed]

Most engine noise is due to jet noise, but high bypass ratio turbofans produce significant fan noise. The high-velocity jet exiting the back of the engine curls up into an annular vortex due to the inherent instability of the shear layer (if the layer is not thick enough). This later develops into confusion. The sound pressure level associated with engine noise is proportional to jet speed (at high power). Therefore, even a small reduction in exhaust velocity significantly reduces jet noise.

The main source of aircraft noise is the engine. The Pratt & Whitney PW1000G helped reduce noise levels on Bombardier C-Series, Mitsubishi MRJ, and Embraer E-Jet E2 crossover narrow body aircraft. The gearbox allows the fan to rotate at the optimal speed. This corresponds to his one-third of the speed of an LP turbine. As a result, the maximum fan speed will be lower. The noise level is 75% lower than current equivalents. The Sukhoi Superjet 100's PowerJet SaM146 features a nacelle with 3D aerodynamic fan blades and a long mixing channel flow nozzle to reduce noise.

2.4.2 Aerodynamic noise [8]

Aerodynamic noise is caused by the flow of air around the vehicle and control surfaces. This type of noise increases with the speed of the aircraft and also at low altitudes due to the force of the wind. Airplanes make a lot of noise from aerodynamics. High-speed, low-flying military aircraft produce intense aerodynamic noise. The shape of the nose, windshield, and fuselage of an aircraft can affect the sound produced. Most of the noise in an airplane comes from aerodynamics, caused by the flow of air around the blades. The main and tail rotors of a helicopter also produce aerodynamic noise. This type of aerodynamic noise is mainly determined by the low speed of the rotor.

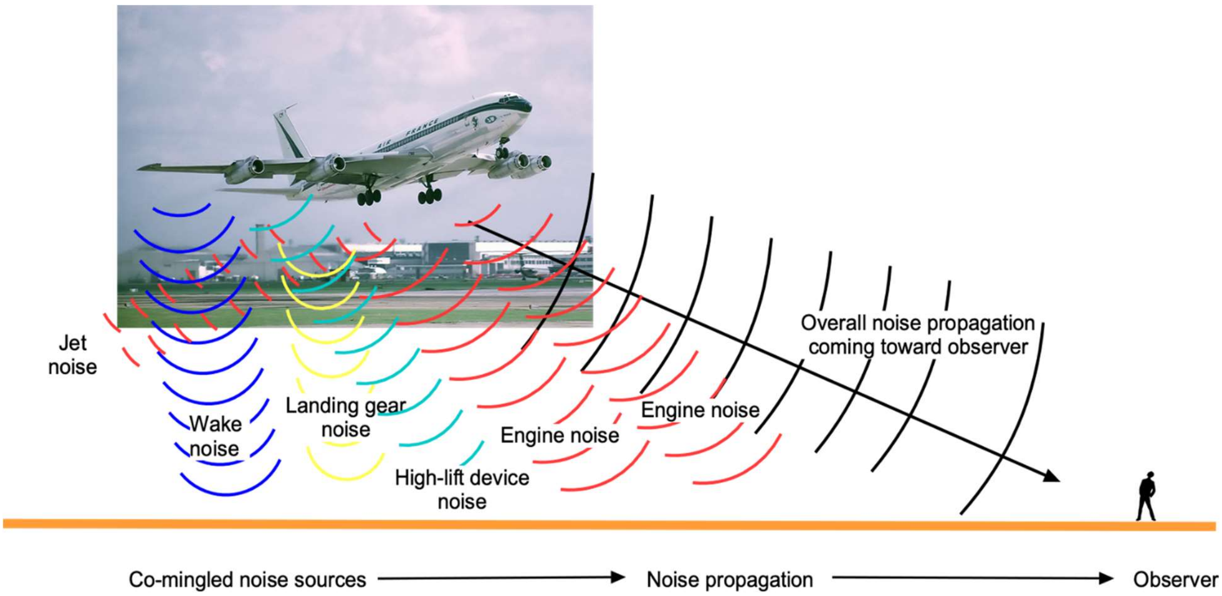

Figure 2-4: An airplane creates several co-mingled noise sources from the engines and airframe. [7]

2.4.3 Noise from aircraft systems:

Cockpit and cabin pressure and regulation systems often play a critical role in the cabins of commercial and military aircraft. However, one of the most significant sources of non-engine cabin noise in commercial aircraft is the auxiliary power unit (APU). This is an onboard generator used to start the main engine on board an aircraft, typically using compressed air to provide power. The plane is on the ground. Other internal aircraft systems may also contribute, such as specialized electronics in some military aircraft.

Chapter 3: Hassi Messaoud Airport: Operations, Weather, and Noise Measurement Points

3.1 About Hassi Messaoud Airport / Oued Irara–Krim Belkacem

Hassi Messaoud / Oued Irara–Krim Belkacem Airport is a medium-sized airport in Ouargla, Algeria. The airport is located at latitude 31.67290 and longitude 6.14038. The airport has a single runway: 18/36. The ICAO code for the airport is DAUH. The IATA code for the airport is HME. The nearest other fields are Hassi Messaoud East Airport, Trczina Airport, Ain Beida Airport, Rhoud El Baguel Airport, and Gassi Touil Airport.

Hassi Messaoud Airport publishes its own METAR. The flight information region (FIR) is Algiers.

Hassi Messaoud Airport is in the Africa/Algiers time zone. The difference with UTC is +1 hour. Today, the sun rises at 05:51 and sets at 19:32. This applies to Hassi Messaoud / Oued Irara–Krim Belkacem Airport; the universal daylight period may vary. The difference between local time and UTC is +1 hour. Daylight saving time is currently in effect. [9]

ICAO	**DAUH**
IATA	**HME**
FIR	**Algiers FIR**
Region	**Ouargla**
Country	**Algeria**
Runways	**18/36**
Type	**Medium sized airport**
Coordinates (ARP)	**314023N 0060826E**
Variation	**2.3° E (2024)**
Time zone	**Algiers (+1 h)**

Table 2: general informations for Hassi Messaoud Airport (HME/DAUH)

Runways:

ID	Real direction	Magnetic cap	Length	Width	Surface	Latitude	Longitude
18	184°	181°	3,000 m	45 m	Asphalt	31,6594	6,1392
36	004°	001°				31.6864	6.1416

Table 3: general informations for Hassi Messaoud Airport Runways

3.2 The movements in Hassi Messaoud / Oued Irara–Krim Belkacem Airport

Hassi Messaoud / Oued Irara–Krim Belkacem Airport (HME) is a key aviation hub located in the Ouargla Province of Algeria. The airport primarily serves the oil industry, connecting Hassi Messaoud with major cities within Algeria and some international destinations. Despite its specialized role, the airport handles a significant number of flights each week, accommodating both passenger and cargo traffic. The volume of flights is driven by the needs of the petroleum sector, facilitating the transportation of personnel and equipment to and from the region. As such, the airport is a vital infrastructure component, supporting the economic activities that are central to Hassi Messaoud's role as a major oil production center.

3.2.1 Number of flights in Hassi Messaoud Airport before the days of measurement

Months / Nature	April	May	June
National	1451	1688	1510
International	45	37	41
Total	1496	1725	1551

Table 4: Number of flights in April, May and June

3.2.2 Number of flights on measurement days at Hassi Messaoud Airport

Types \ Days	14	15	16	17	18	19	20	21	22	23	Total
B737-800	14	09	18	20	06	08	15	14	04	20	**128**
B737-600	00	02	01	00	00	00	00	00	02	02	**07**
ATR75	01	03	02	01	01	03	01	01	03	03	**19**
ATR72	01	05	01	06	02	04	01	03	02	00	**25**
BE1900	07	10	18	24	11	11	11	06	13	19	**130**
L410	02	04	06	07	08	04	06	00	08	08	**53**
DHC6	05	04	08	07	05	08	06	04	06	08	**61**
DH8B	02	02	01	01	01	01	00	01	02	02	**13**
DH8D	00	02	05	05	01	01	03	01	06	03	**27**
PC6T	02	02	02	01	00	02	02	02	02	00	**15**
DA40	02	02	00	01	02	02	01	00	00	02	**12**
DA42	00	00	00	00	00	00	01	00	00	00	**01**
B206L	01	00	02	01	01	01	02	01	02	00	**11**
C208	00	04	00	04	01	00	05	01	00	04	**19**
CRJ2	00	00	02	00	02	00	00	00	00	02	**06**
C56X	00	00	00	02	01	00	00	00	01	02	**06**
TOTAL	**37**	**49**	**66**	**80**	**42**	**45**	**54**	**34**	**51**	**75**	**533**

Table 5: Number of flights per the type of the Aircraft in the days of measurement

We notice here that the days with the highest number of flights 16,17 and 23 July (Tuesday and Wednesday) that’s why we took only the day Tuesday 23 July in the second week of measurement.

3.3 Meteorological conditions encountered during the measurements

The meteorological conditions during the measurement periods are summarized in the table below. The meteorological data are sourced from the 'Allmetsat' website

Date	Period	Temperature	Pressure	Humidity	Wind
14/07/2024	9h_11h	45 °C	1012 hPa	7%	6 kt southwest
15/07/2024	14h_15h	49 °C	1009 hPa	13%	12 kt west/northwest
16/07/2024	8h_9h	38 °C	1011 hPa	20%	9 kt east/southeast
	9h_10h	43 °C		13%	7 kt southeast
17/07/2924	8h_10h	39 °C	1013 hPa	11%	6 kt south/southeast
	10h_11h	45 °C	1014 hPa	14%	4 kt south
23/07/2024	6h_8h	30 °C	1013 hPa	46%	10 kt east/northeast
	8h_9h	32 °C	1015 hPa	36%	11 kt east/northeast

Table 6: The Meteorological conditions encountered during the measurements

3.4 The location of the 5 measurement points in Hassi Messaoud Airport

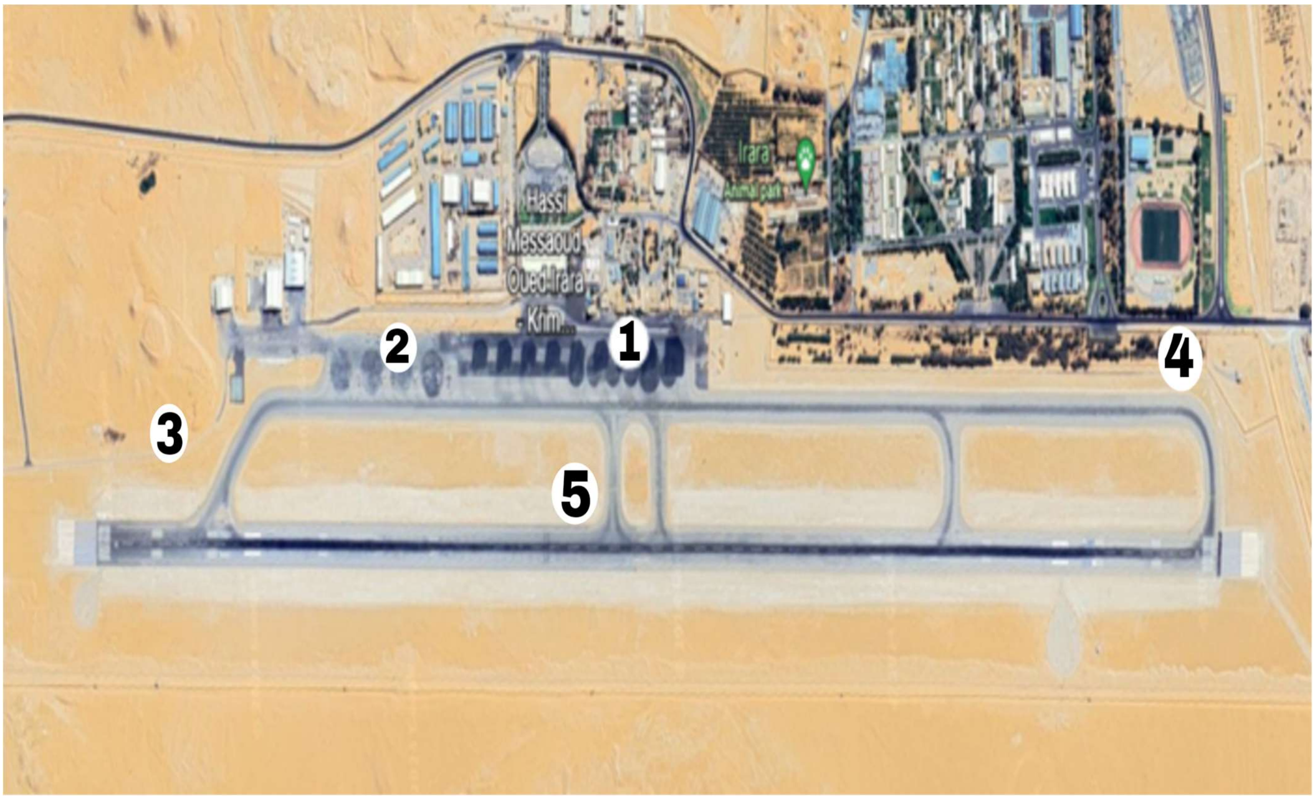

Figure 3-1: The location of the five measurement points

1: parking (A) for medium and large aircraft

2: parking (B) for light aviation

3: Measurement point approximately 100 meters to the left of runway 18

4: Measurement point approximately 205 meters to the right of runway 36

5: measurement point approximately 20m to the right of the holding point and 50m to the left of the runway axis

Chapter 4 Methodology and Measurement Results

4.1 Introduction

In this part we will measure the noise in airport of Hassi Messaoud (Krim Belkacem) in different points in the airport as we saw in Figure 3-1, we will measure the noise in this airport between July 14 and July 23 especially in Tuesday and Wednesday when the noise reaches the highest level to see if the noise pollution exceeded the limits prescribed in Annex 16 of the ICAO and the WHO.

4.2 Measuring equipment used

The noise measurements were carried out using a certified and calibrated sound level meter, the main characteristics of which are presented in the following table:

Device	Sound Meter
Brand	SM-20A
Microphone	1/2 Electret condenser microphone
Standard applied	IEC 651 Type 2, ANSI 1.4 Type 2
Dynamic range	50 dB
Time weighting	Fast (125 mS), Slow (1 sec)
Frequency range	31.5 Hz → 8 kHz
Measuring level range	(Auto Range) A-Weighting: 30 dB → 130 dB C-Weighting: 35 dB → 130 dB
Data	Min/max
Internal memory	14,000 records

table 7: Specifications of the Sound meter used

4.3 Measurements of the points

4.3.1 Day 14 July Measurements of the point 1

4.3.1.1 Taxiing and take off of the aircraft ATR 72 at the point 1

time of measurement	aircraft type	flight phase	Maximum dbA value	Minimum dbA value
09:25 UTC	ATR 72	Taxiing and Take-off	94.5 dbA	66.1 dbA

Table 8: Taxiing and Take-off of the ATR 72

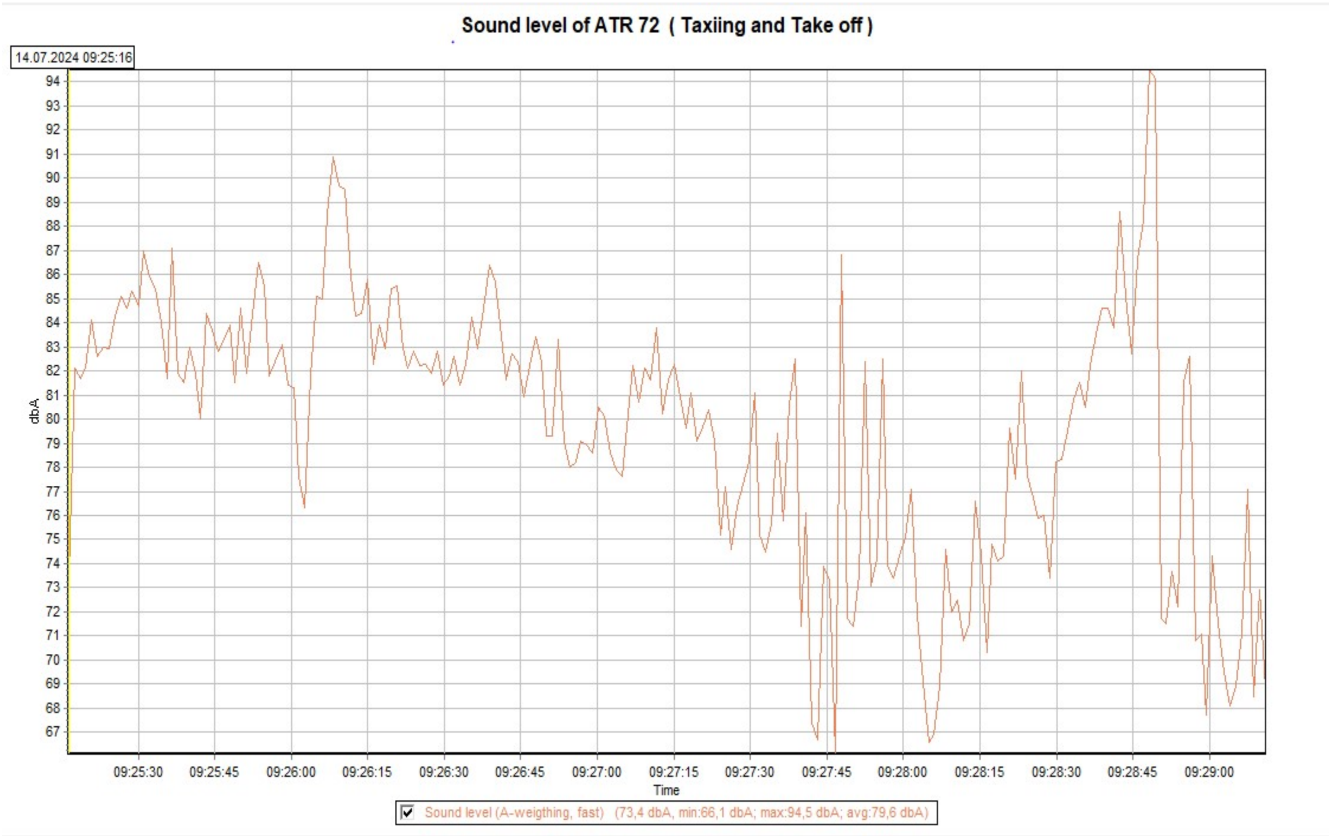

Figure 4-1: Noise measurement result of the Taxiing and Take-off of the ATR 72

The figure shows the sound level of an ATR 72 aircraft during taxiing and takeoff. The sound level is measured in dB(A) and is plotted against time. The graph shows that the sound level fluctuates significantly, reaching a peak of 94.5 dB(A) during takeoff. The average sound level is 79.6 dB(A).

4.3.1 Day 14 July Measurements of the point 1

4.3.1.2 Startup of the aircraft boing 737-800 at the point 1

Time of measurement	Aircraft type	Flight phase	Maximum dbA value	Minimum dbA value
10:07 UTC	Boeing 737-800	Startup	92.1 dbA	70.9 dbA

Table 9: Startup of the Boeing 737-800

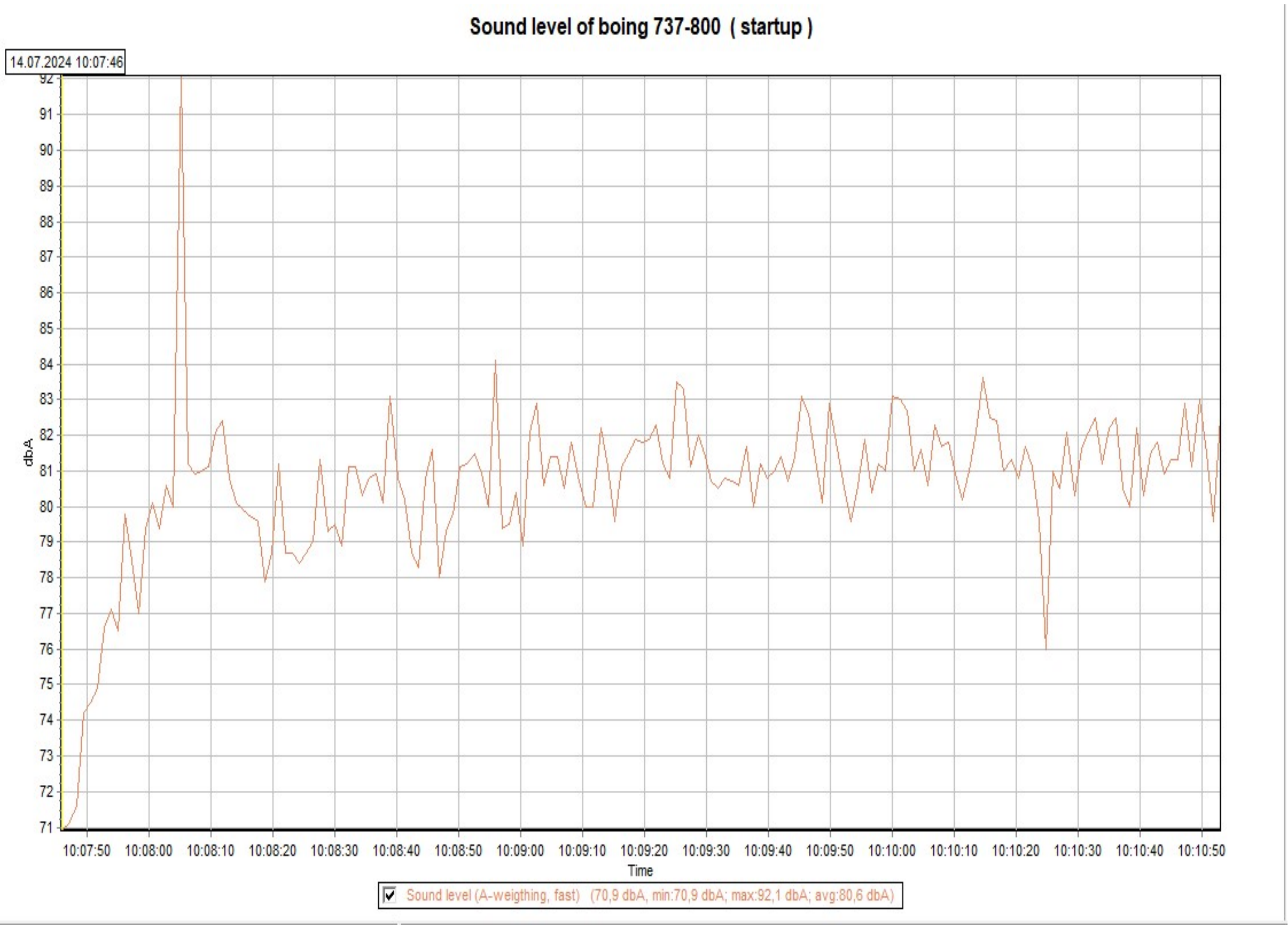

Figure 4-2: Noise measurement results of the Startup of Boeing 737-800

The figure is a graph showing the sound level of a Boeing 737-800 during startup. The graph shows that the sound level starts at around 73 dBA and quickly rises to 92 dBA, before settling down to around 80 dBA. The graph also shows that the sound level fluctuates slightly, but remains relatively stable after the initial startup. This data could be used to understand the noise impact of the aircraft during startup and to develop noise reduction strategies.

4.3.2 Day 14 July Measurements of the point 3

4.3.2.1 Taxiing and take off of the aircraft Boing 737-800 at the point 3

Time of measurement	Aircraft type	Flight phase	Maximum dbA value	Minimum dbA value
10:12 UTC	Boeing 737-800	Taxiing and Take-off	97.6 dbA	58.0 dbA

Table 10: Taxiing and Take-off of the Boeing 737-800

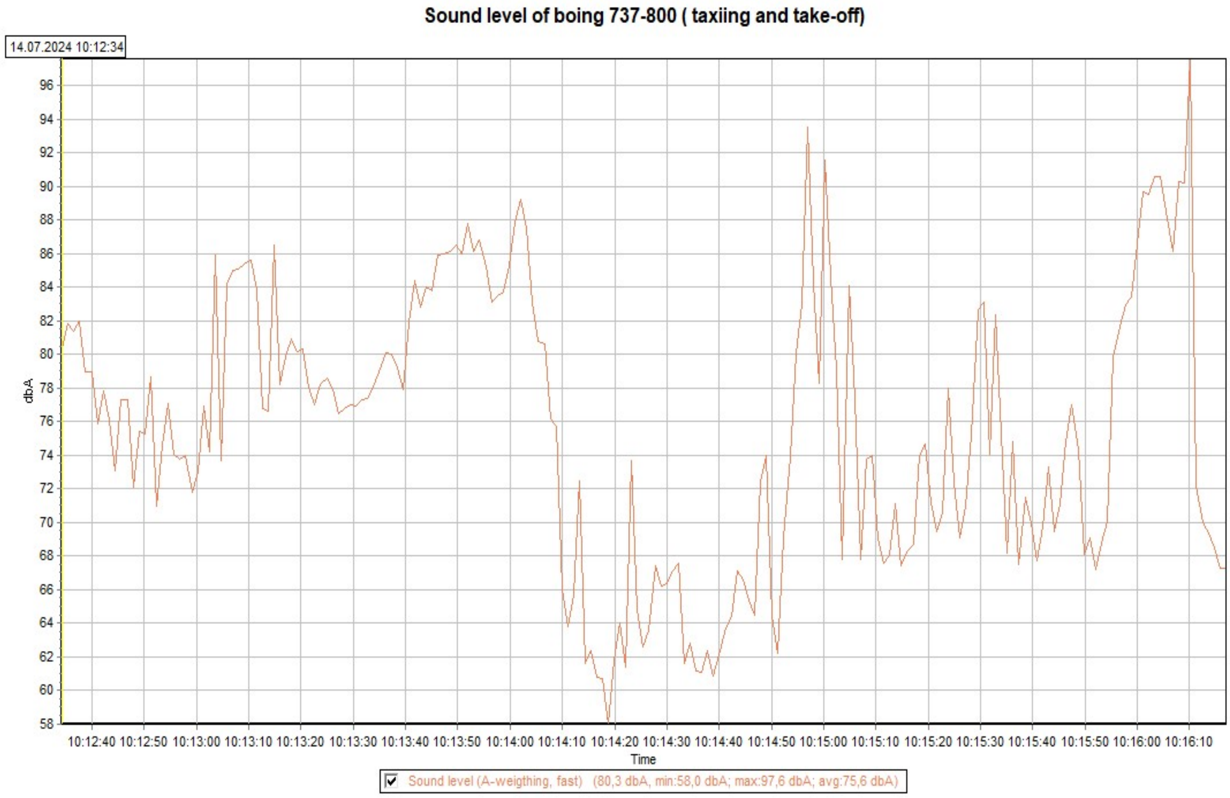

Figure 4-3: Noise measurement result of the Taxiing and Take-off of the Boeing 737-800

A graph of the sound level of a Boeing 737-800 during taxiing and take-off. The x-axis shows the time, while the y-axis shows the sound level in decibels (dbA).

The graph shows that the sound level increases significantly during take-off, peaking at around 97.6 dbA. After take-off, the sound level decreases to around 75.6 dbA. The graph also shows some fluctuations in sound level during taxiing, with the sound level generally increasing as the airplane speeds up. The graph does not cover the entire period of take-off and landing, but rather shows just a portion of the process.

4.3.3 Day 15 July Measurements of the point 2

4.3.3.1 Taxiing of the aircraft PILATUS (PC6T) at the point 2

Time of measurement	Aircraft type	Flight phase	Maximum dbA value	Minimum dbA value
14:34 UTC	PILATUS	Taxiing	84.0 dbA	32.4 dbA

Table 11: Taxiing of the PILATUS (PC6T)

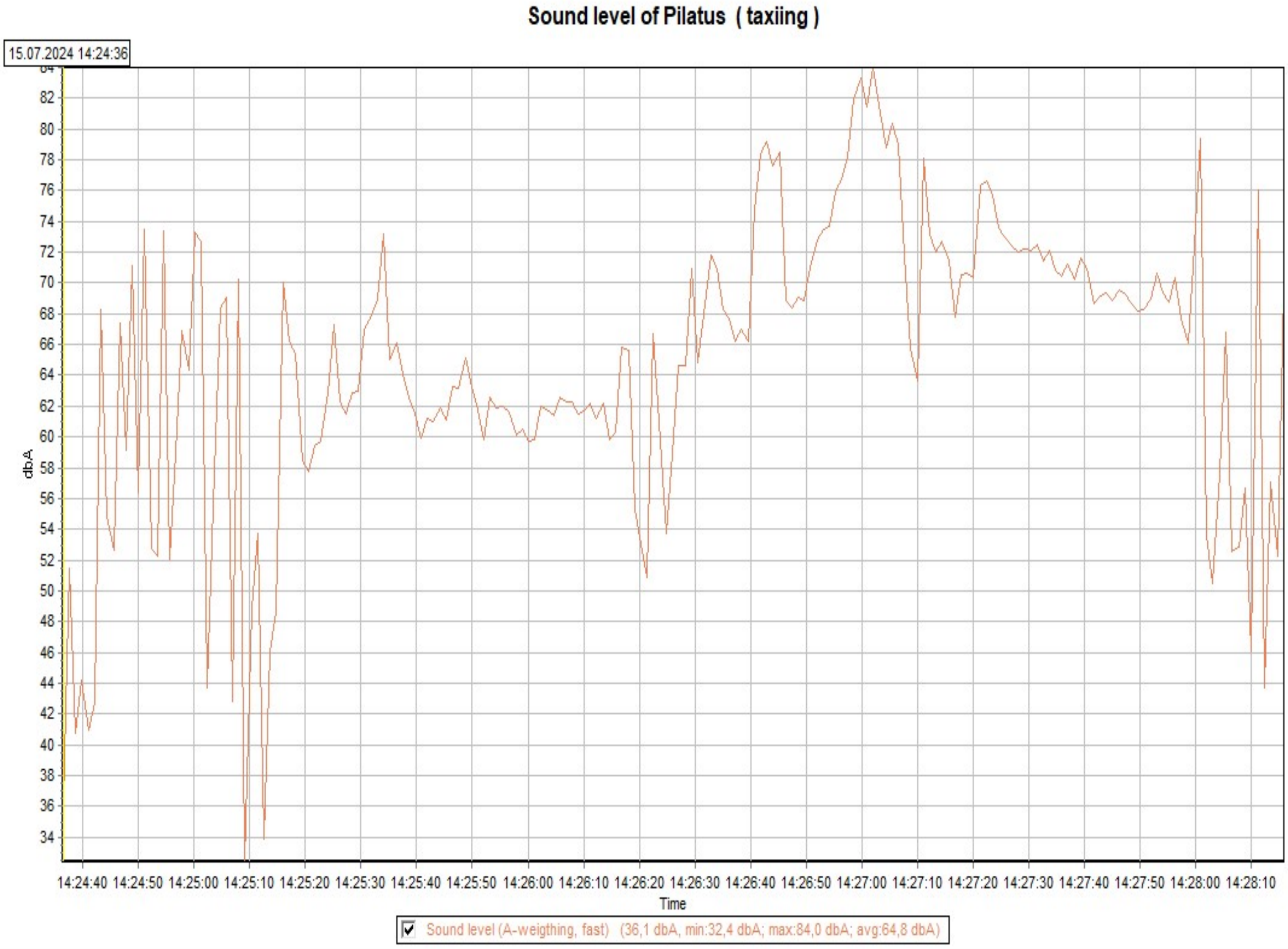

Figure 4-4: Noise measurement results of the Taxiing of PILATUS (PC6T)

The figure shows the sound level of a Pilatus aircraft while taxiing. The sound level is measured in decibels (dBA) and is plotted against time. The sound level fluctuates between 32.4 dBA and 84.0 dBA, with an average of 64.8 dBA. The graph indicates that the Pilatus aircraft was quite noisy during taxiing. The noise was mixed with the noise of the vehicle near our location so the real measure was from 14:25:10

4.3.3 Day 15 July Measurements of the point 2

4.3.3.2 Startup and Taxiing of the aircraft DHC6 at the point 2

Time of measurement	Aircraft type	Flight phase	Maximum dbA value	Minimum dbA value
14:48 UTC	DHC6	Startup and Taxiing	93.8 dbA	55.0 dbA

Table 12: Startup and Taxiing of the DHC6

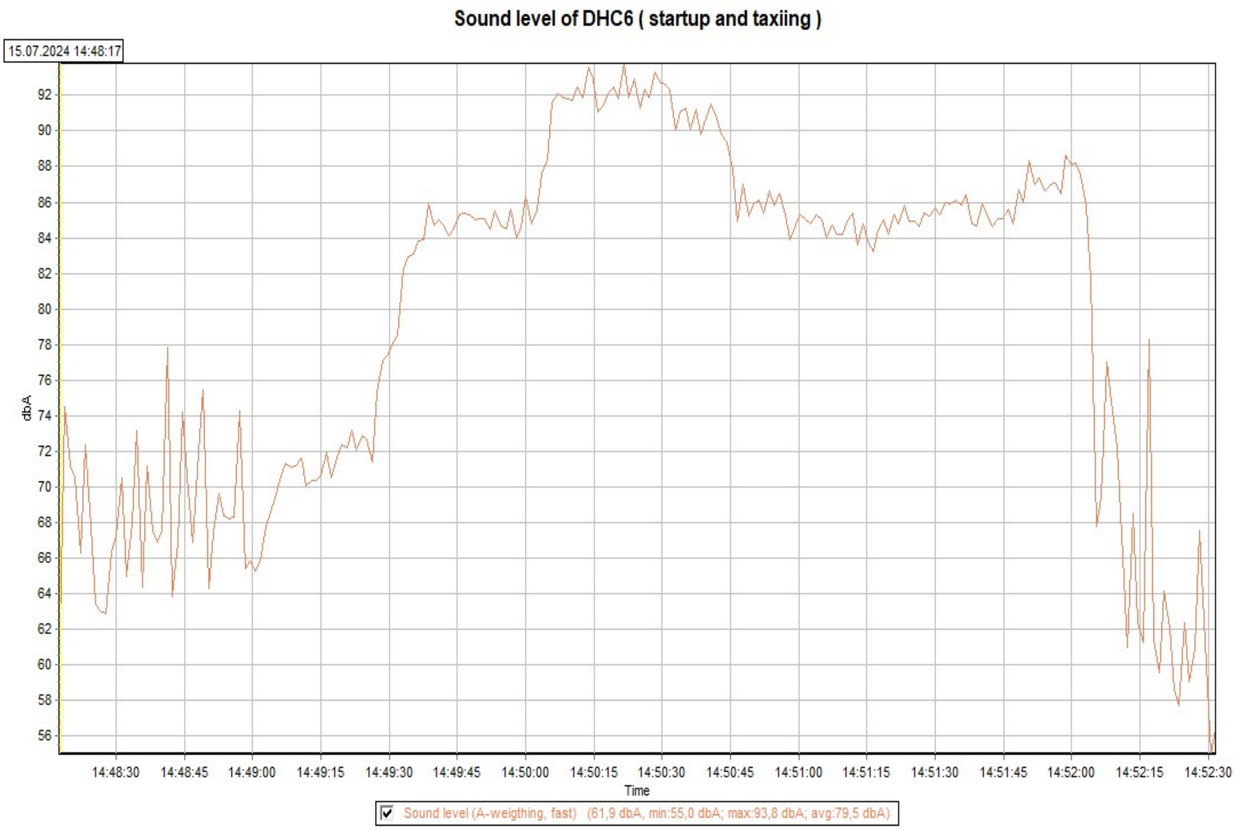

Figure 4-5: Noise measurement result of the Startup and Taxiing of the DHC6

The graph shows the sound level of a DHC6 aircraft during startup and taxiing. The sound level is measured in dBA (decibels A-weighted), and the time is shown on the x-axis. The sound level starts at around 60 dBA and increases to around 90 dBA during startup, then decreases to around 80 dBA during taxiing. The graph shows that the sound level is variable, with peaks and valleys. This is likely due to the engine's RPM changing during startup and taxiing. The graph also shows that the aircraft is quite noisy, with a maximum sound level of 93.8 dBA.

4.3.4 Day 16 July Measurements of the point 4

4.3.4.1 Take off of bombardier CRJ-1000 at the point 4

Time of measurement	Aircraft type	Flight phase	Maximum dbA value	Minimum dbA value
08:58 UTC	CRJ-1000	Take-off	87.4 dbA	42.8 dbA

Table 13: Take-off of the CRJ-1000

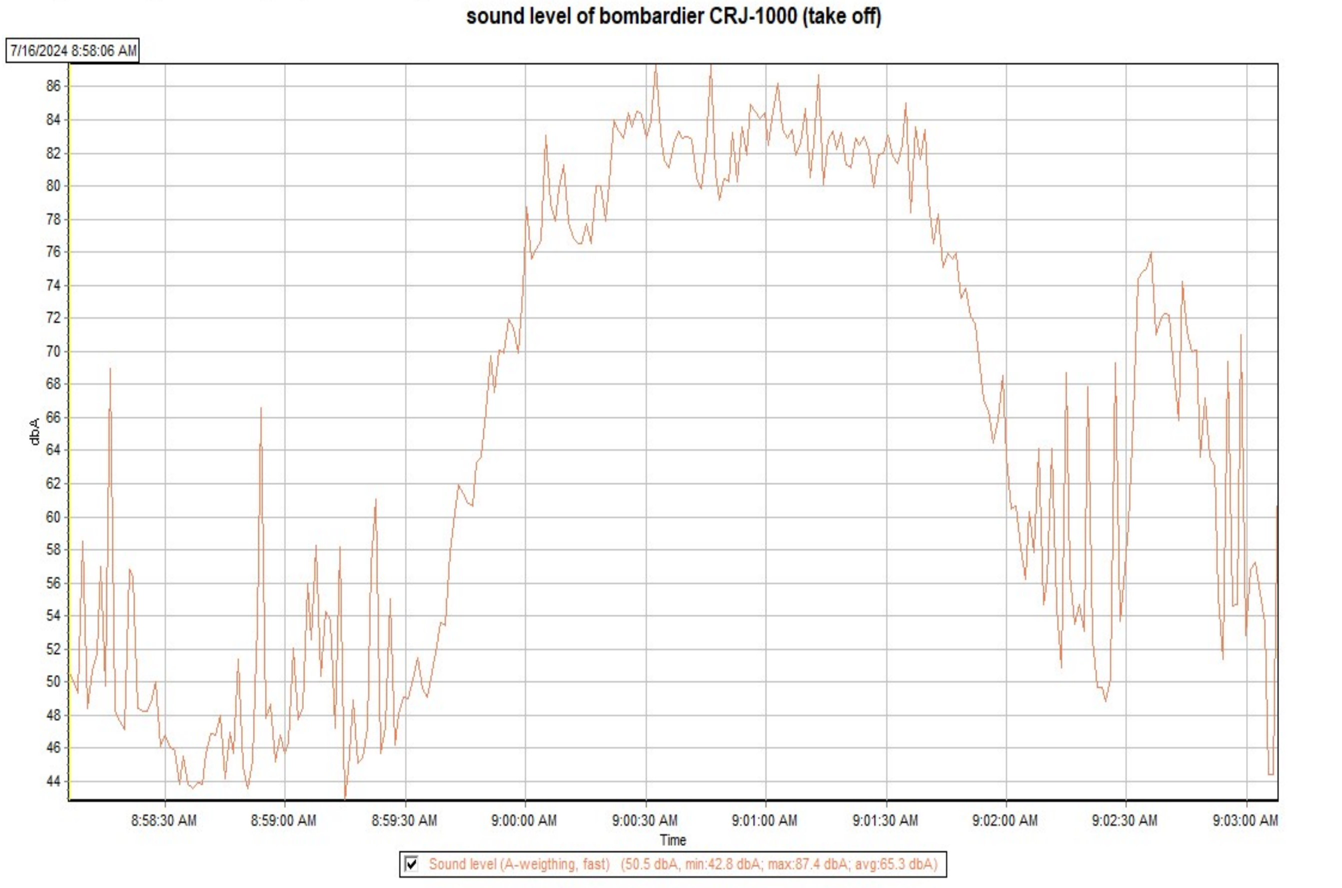

Figure 4-6: Noise measurement result of the Take-off of the Bombardier CRJ-1000

This figure shows a graph of the sound level of a Bombardier CRJ-1000 airplane as it takes off. The graph shows that the sound level rises rapidly in the first few minutes of takeoff, then begins to decrease as the plane gains altitude.

4.3.5 Day 16 July Measurements of the point 1

4.3.5.1 Take-off of Boeing 737-800 at point 1

Time of measurement	Aircraft type	Flight phase	Maximum dbA value	Minimum dbA value
09:57 UTC	Boeing 737-800	Take-off	87.6 dbA	56.1 dbA

Table 14: Take-off of the Boeing 737-800

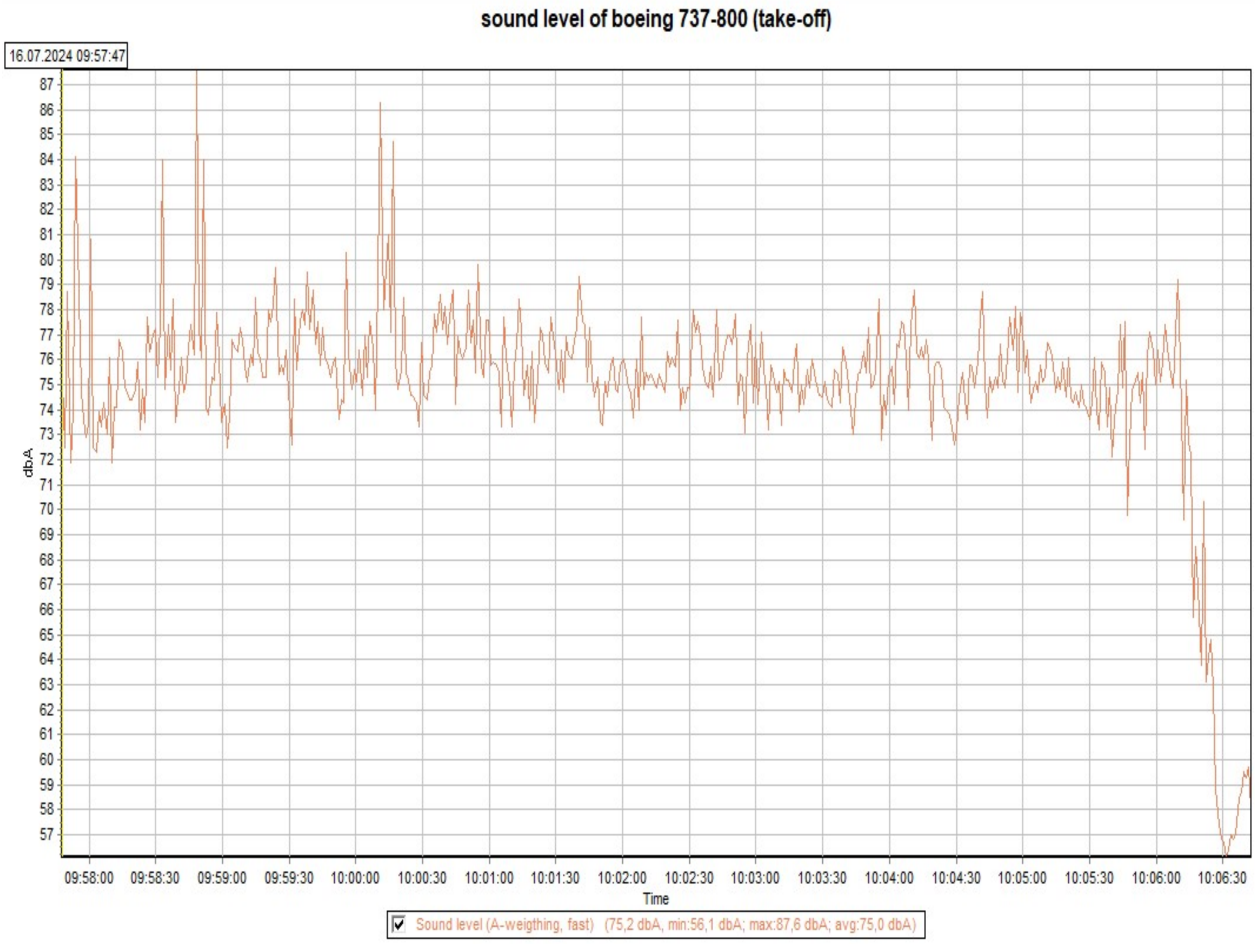

Figure 4-7: Noise measurement result of the Take-off of the Boeing 737-800

The figure shows a graph of the sound level of a Boeing 737-800 during take-off. The graph shows that the sound level increases sharply during the take-off, reaching a peak of 87.6 dBA, then gradually decreases after the plane has taken off. The average sound level during the take-off is 75.0 dBA.

4.3.6 Day 16 July Measurements of the point 3

4.3.6.1 Taxiing and Take-off of DHC6 and landing of DH8B (Q200) at the point 3

Time of measurement	Aircraft type	Flight phase	Maximum dbA value	Minimum dbA value
09:36 UTC	DHC6	Taxiing and Take-off	86.4 dbA	47.5 dbA
	DH8B	Landing		

Table 15: Taxiing and Take-off of the DHC6 and Landing of the DH8B

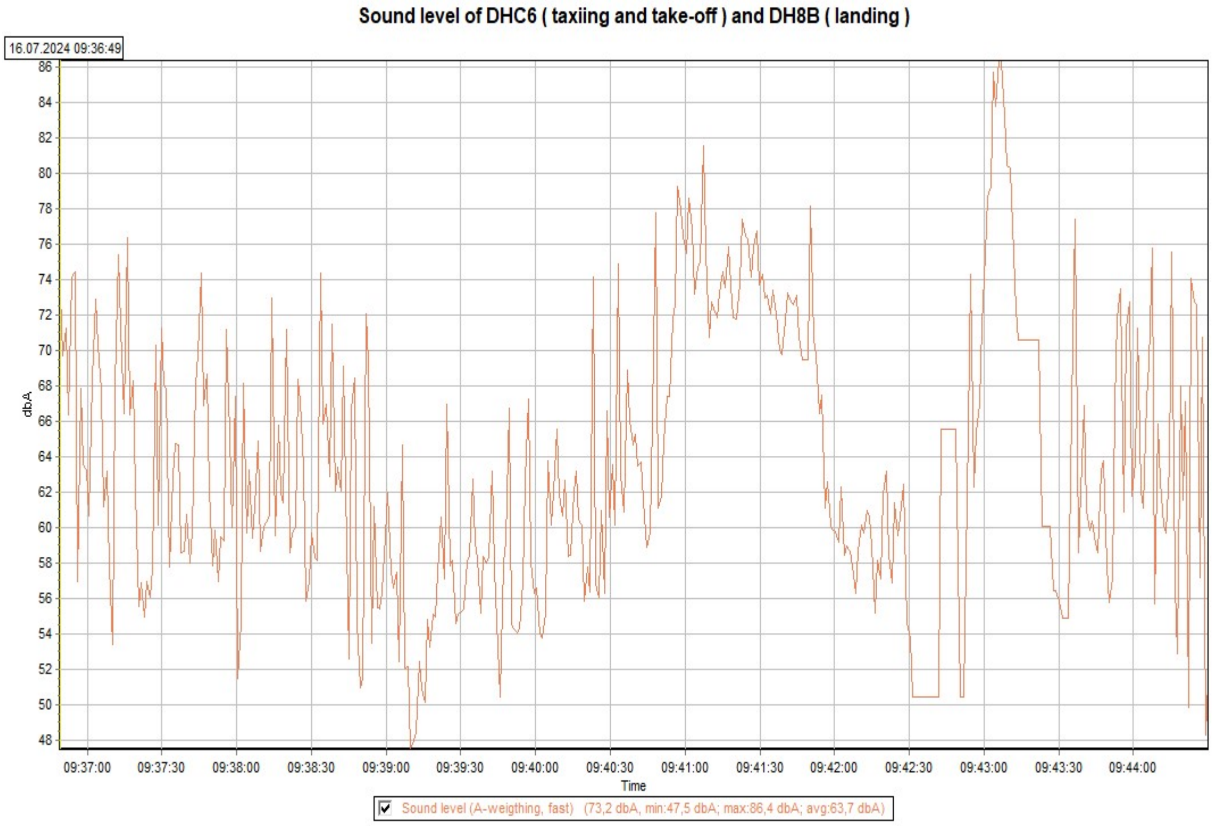

Figure 4-8: Noise measurement result of Taxiing and Take-off of DHC6 and Landing of DH8B

The figure shows a graph of sound levels measured over time. The graph shows the sound level of a DHC6 aircraft taxiing and taking off, and a DH8B aircraft landing. The sound level is measured in dBA (decibels A-weighted) and the time is shown on the x-axis in hours and minutes. The maximum sound level reached was 86.4 dBA, while the minimum sound level was 47.5 dBA. The average sound level was 63.7 dBA.

4.3.7 DAY JULY 17 Measurements of the point 05

4.3.7.1 Landing of DH8D (Q400) at the point 5

Time of measurement	Aircraft type	Flight phase	Maximum dbA value	Minimum dbA value
08:18 UTC	DH8D	Landing	91.2 dbA	53.7 dbA

Table 16: Landing of the DH8D

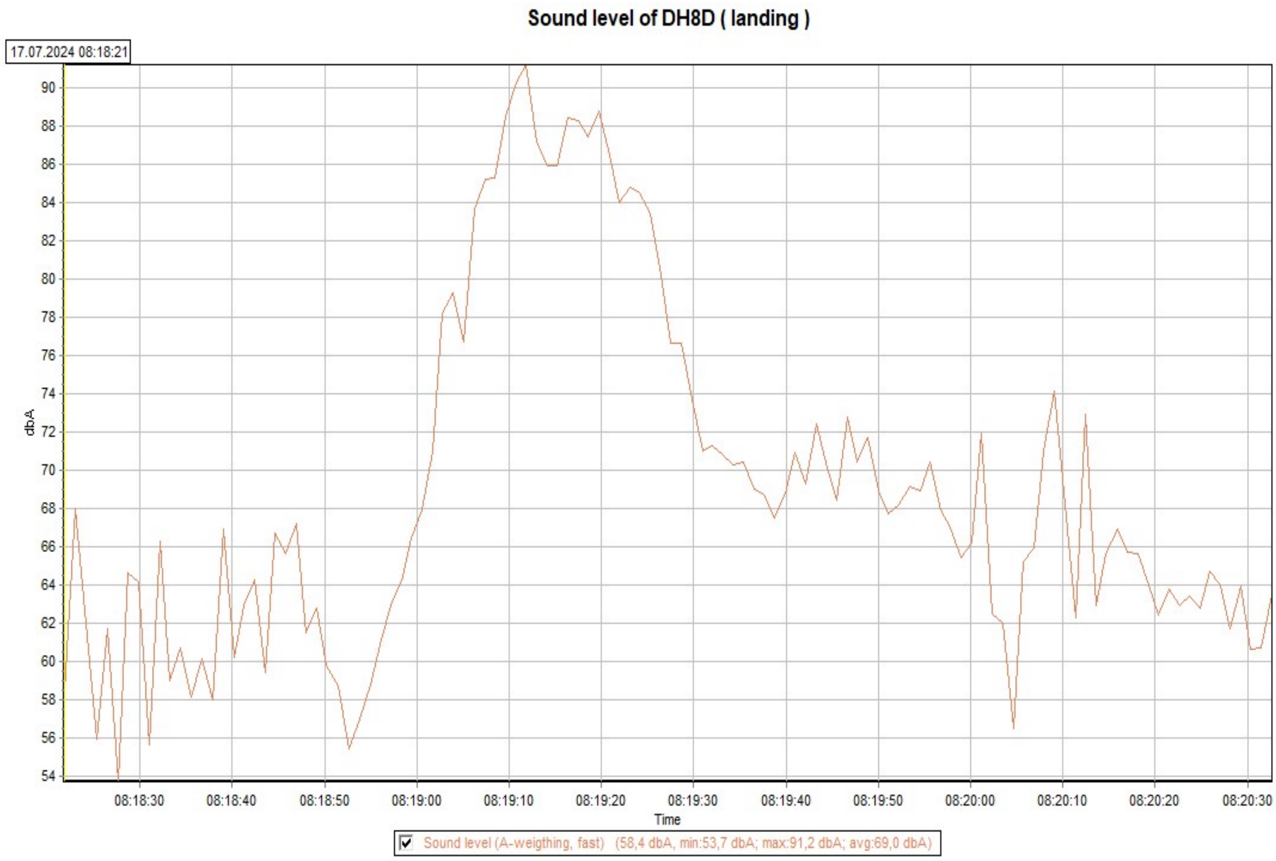

Figure 4-9: Noise measurement result of the Landing of DH8D (Q400)

The figure shows the sound level of a DH8D aircraft during landing. The sound level is measured in dBA (decibel A-weighted) and is plotted against time. The sound level starts at around 60 dBA and gradually increases to over 90 dBA as the aircraft approaches landing. It then decreases to around 60 dBA as the aircraft comes to a stop. The peak sound level is around 91 dBA and the average sound level is 69 dBA.

4.3.7 DAY JULY 17 Measurements of the point 5

4.3.7.2 Take-off of the CESSNA 560XL at the point 05

Time of measurement	Aircraft type	Flight phase	Maximum dbA value	Minimum dbA value
08:34 UTC	Cessna 560XL	Take-off	89.1 dbA	53.1 dbA

Table 17: Take-off of the Cessna 560XL

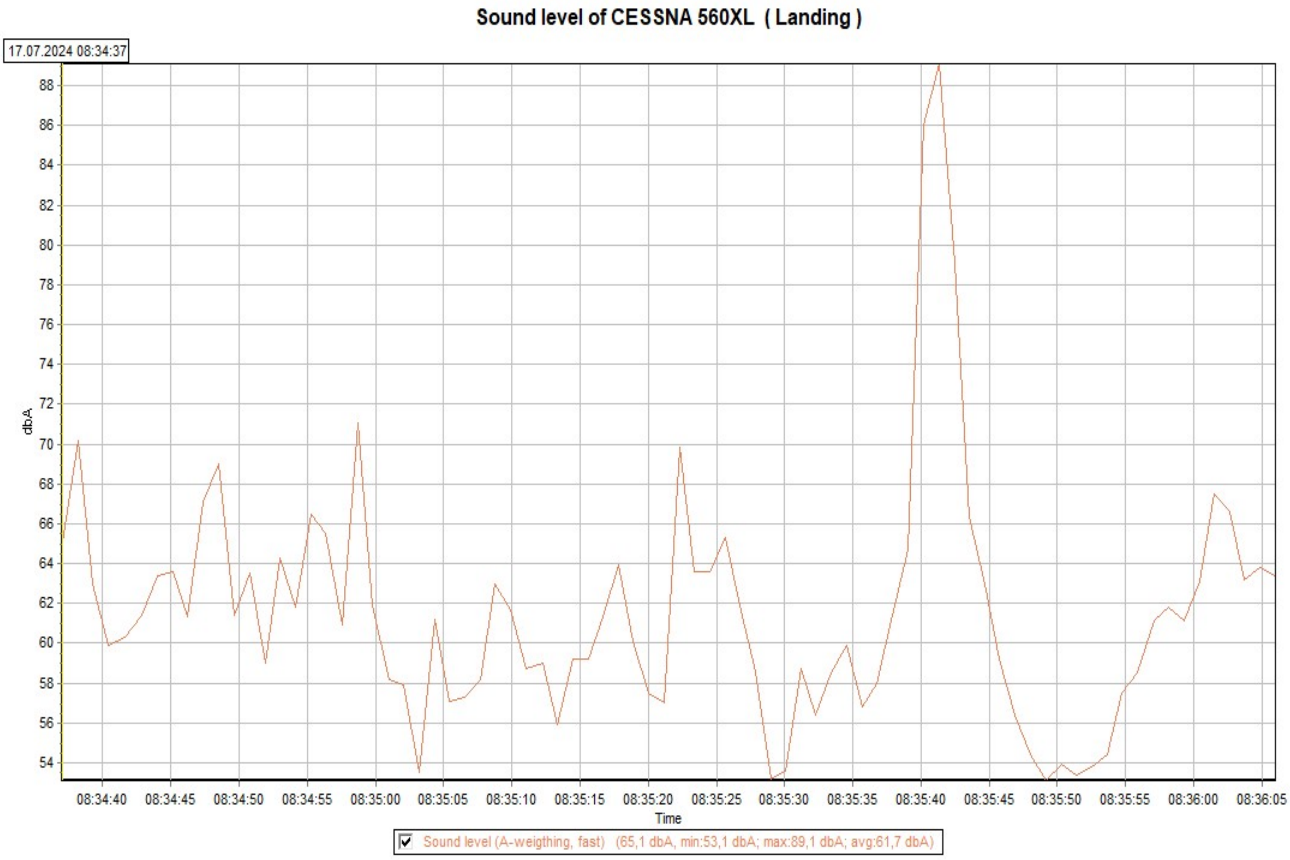

Figure 4-10: Noise measurement result of the Take-off of Cessna 560XL

The figure shows the sound level of a Cessna 560XL during landing. The sound level is measured in decibels (dBA) and is plotted over time. The graph shows that the sound level is relatively low at the beginning of the landing, but it increases rapidly as the aircraft approaches the ground. The sound level peaks at around 89 dBA, which is a very loud noise. The aircraft then descends below the sound level of 70 dBA.

4.3.7 DAY JULY 17 Measurements of the point 5

4.3.7.3 Taxiing and Take-off of the ATR 72 at the point 5

Time of measurement	Aircraft type	Flight phase	Maximum dbA value	Minimum dbA value
08:37 UTC	ATR 72	Taxiing and Take-off	93.1 dbA	46.6 dbA

Table 18: Taxiing and Take-off of the ATR 72

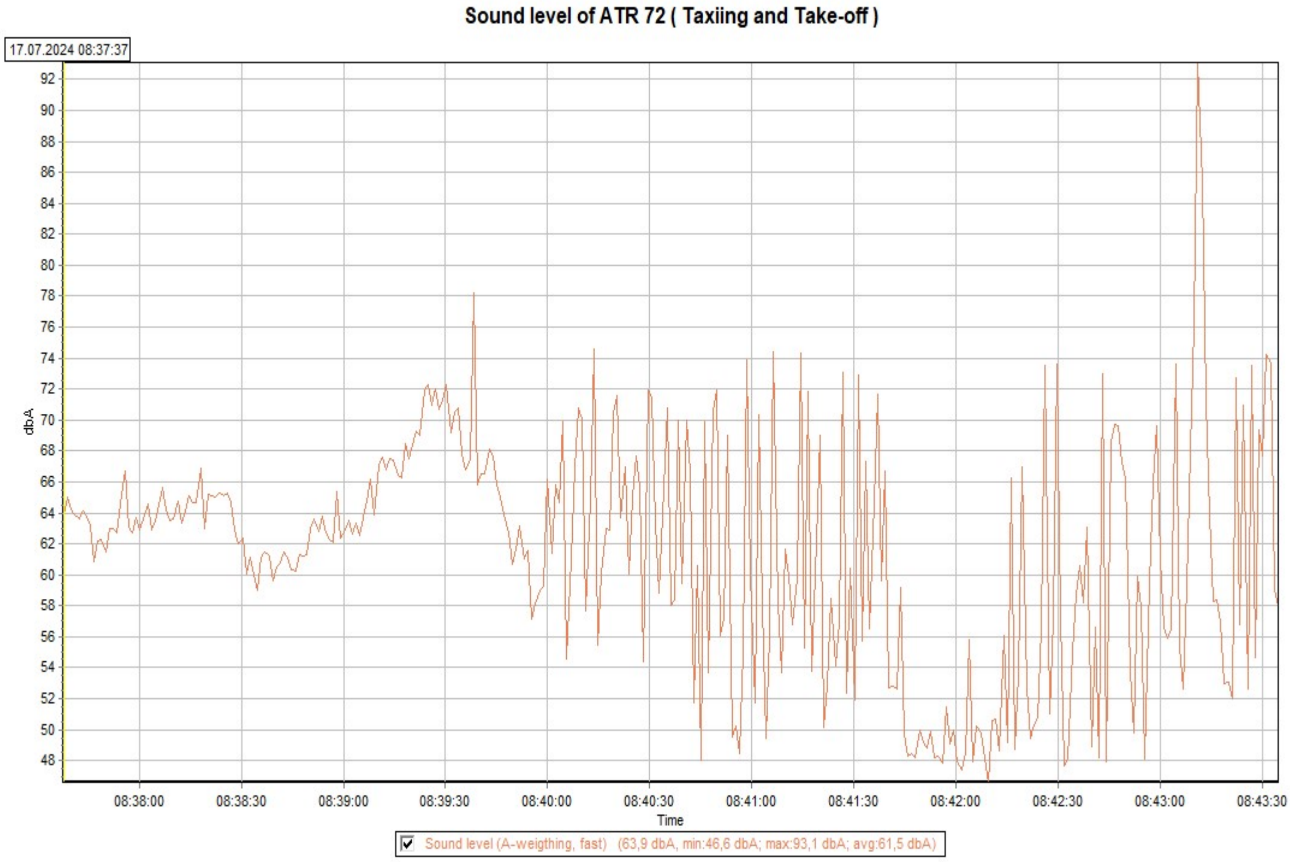

Figure 4-11: Noise measurement result of the Taxiing and Take-off of the ATR 72

This figure is a graph that shows the sound level of an ATR 72 airplane as it taxies and takes off. The x-axis represents time, and the y-axis represents the sound level in decibels (dBA). The graph shows that the sound level fluctuates over time, with peaks in the sound level occurring during the takeoff phase. The graph also indicates the minimum, maximum, and average sound levels measured during the recording. From 8:41:30 to 8:42:00 the aircraft went from the point 1 to point 3 that’s why it became low.

4.3.8 DAY JULY 17 Measurements of the point 1

4.3.8.1 Startup, taxiing and take-off of the DH8D (Q400) at the point 1

Time of measurement	Aircraft type	Flight phase	Maximum dbA value	Minimum dbA value
08:52 UTC	DH8D	Startup, Taxiing and Take-off	94.4 dbA	45.1 dbA

Table 19: Startup, Taxiing and Take-off of the DH8D

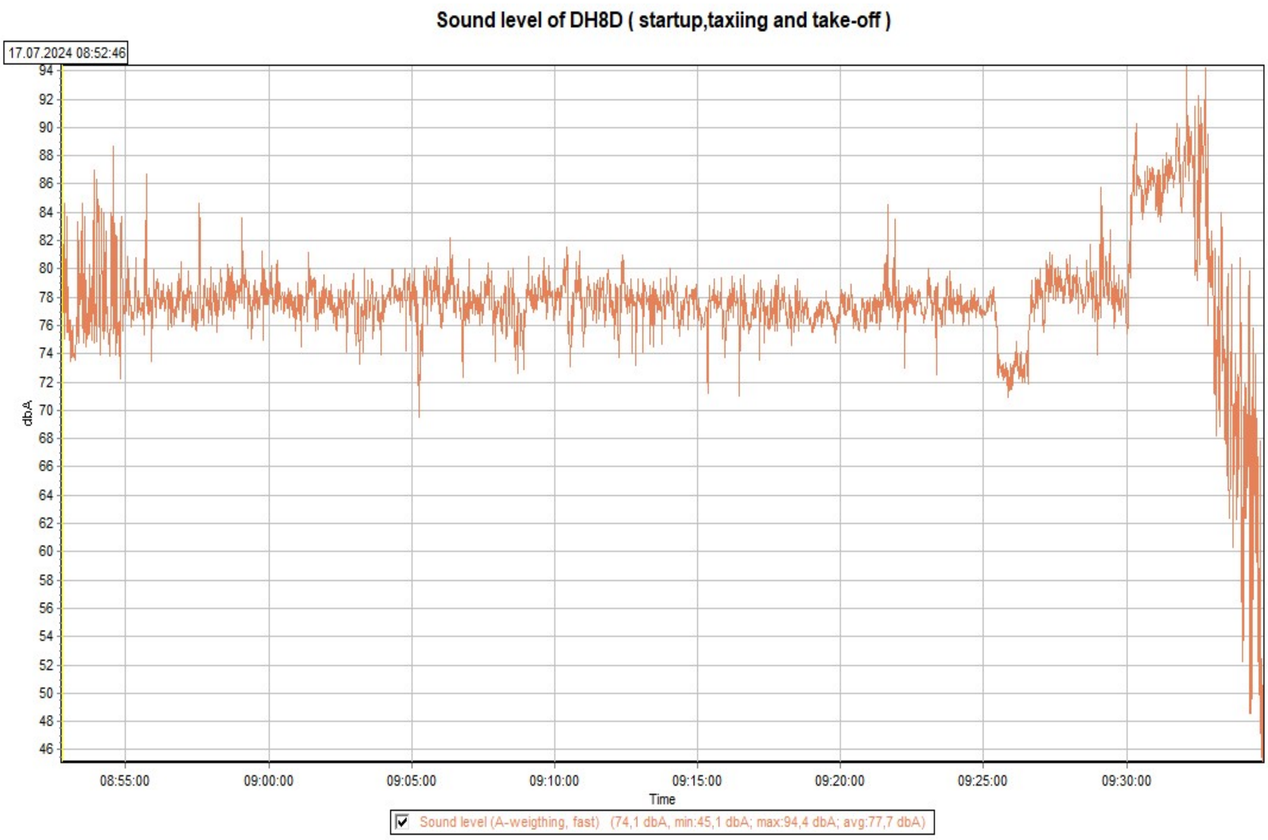

Figure 4-12: Noise measurement result of the Startup, Taxiing and Take-off of the DH8D (Q400)

This figure is a graph that shows the sound level of a DH8D aircraft during startup, taxiing, and takeoff. The sound level is measured in decibels (dBA) and is plotted against time. The graph shows that the sound level increases significantly during the takeoff phase of the flight. The minimum sound level is 45.1 dBA, the maximum sound level is 94.4 dBA, and the average sound level is 77.7 dBA.

4.3.8 DAY JULY 17 Measurements of the point 1

4.3.8.2 Landing of the Beechcraft 1900 at the point 1

Time of measurement	Aircraft type	Flight phase	Maximum dbA value	Minimum dbA value
10:29 UTC	Beechcraft 1900	Landing	91.4 dbA	41.5 dbA

Table 20: Landing of the Beechcraft 1900

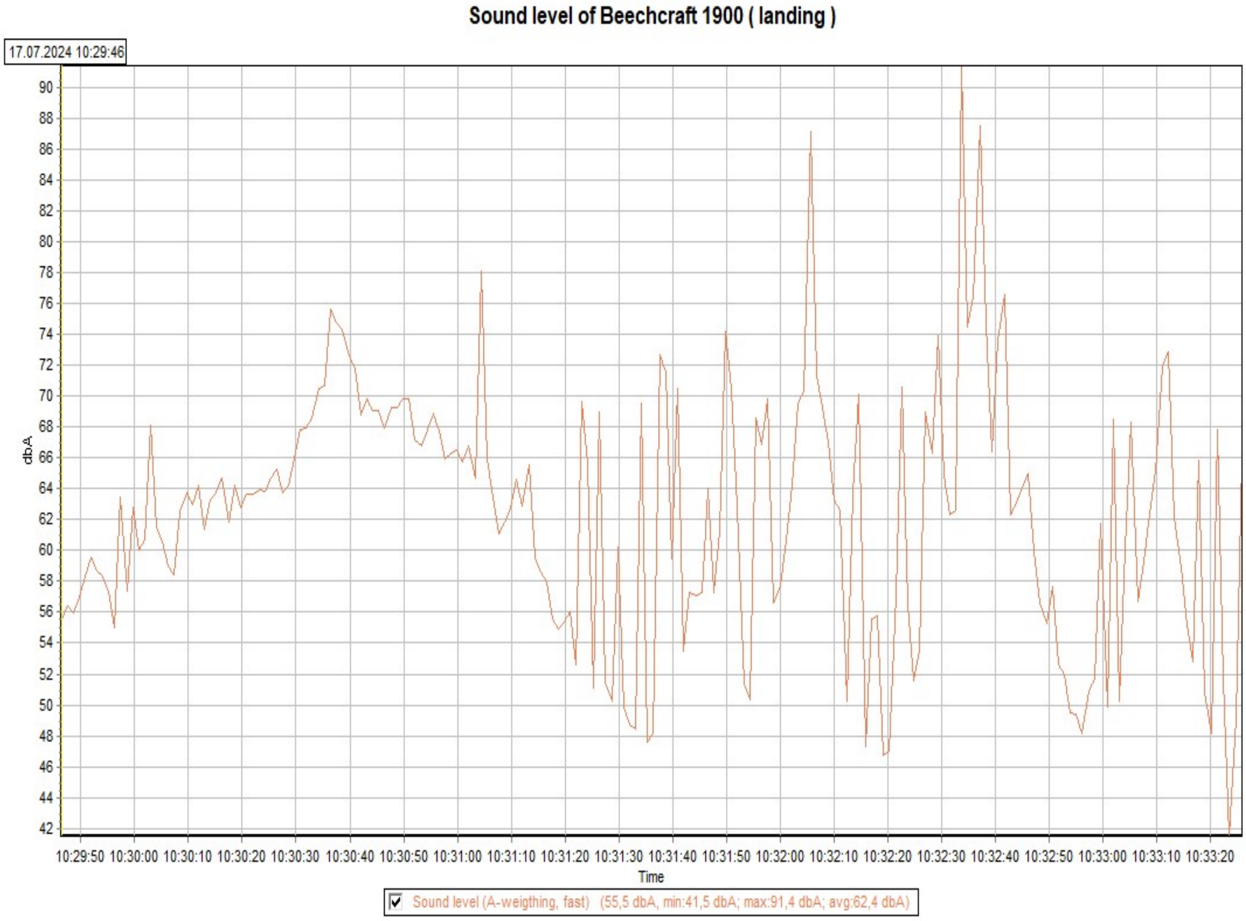

Figure 4-13: Noise measurement result of the Landing of the Beechcraft 1900

This figure shows a graph of the sound level of a Beechcraft 1900 airplane during a landing. The graph shows that the sound level fluctuates over time, with peaks and valleys. The highest sound level recorded is 91.4 dBA. The average sound level is 62.4 dBA.

4.3.8 DAY JULY 17 Measurements of the point 1

4.3.8.3 Landing of Boing 737-800 at the point 1

Time of measurement	Aircraft type	Flight phase	Maximum dbA value	Minimum dbA value
10:35 UTC	Boeing 737-800	Landing	85.8 dbA	41.6 dbA

table 21: Landing of Boeing 737-800

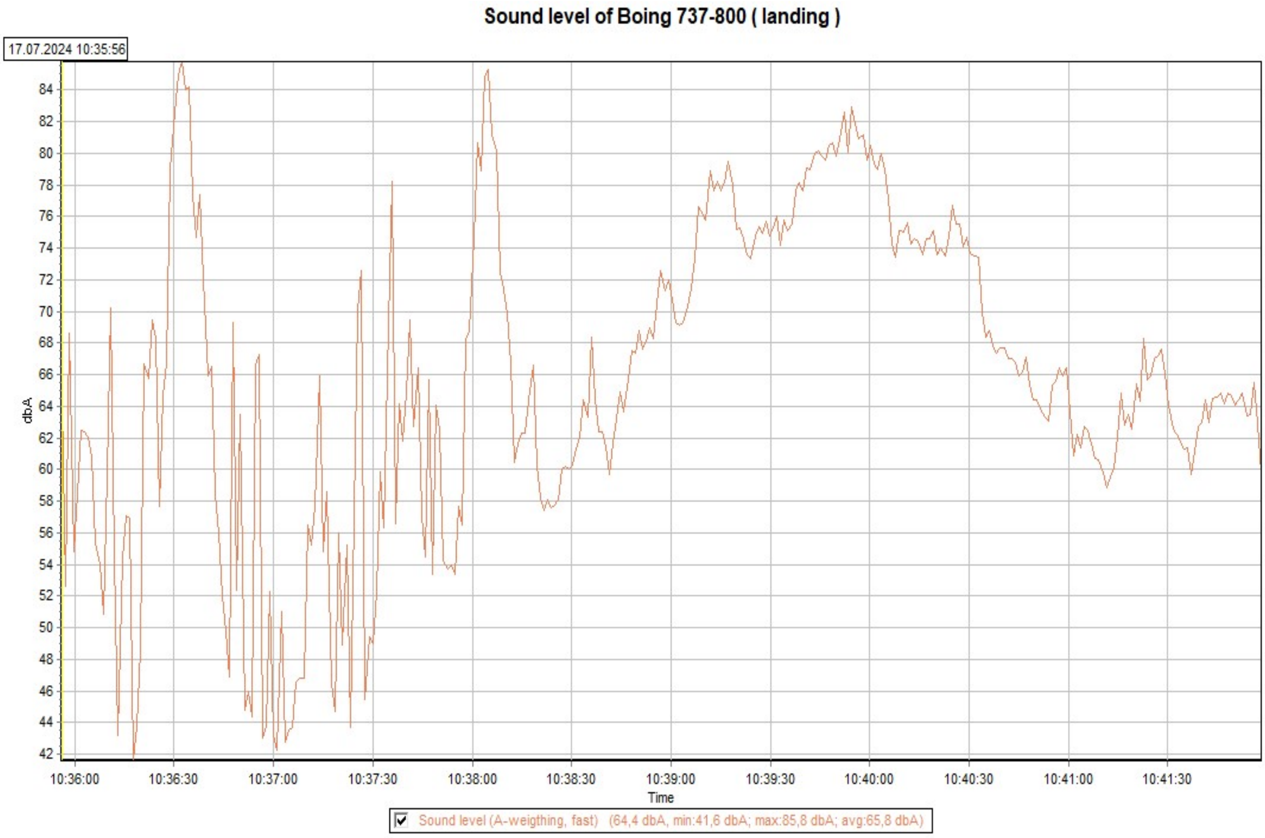

Figure 4-14: Noise measurement result of the Landing of the Boeing 737-800

The figure shows a graph of the sound level of a Boeing 737-800 during landing. The sound level is measured in decibels (dBA) and is plotted against time. The graph shows that the sound level increases as the plane approaches the ground, reaching a peak of 85.8 dBA just before landing. The sound level then drops sharply as the plane comes to a stop. The average sound level during landing was 65.8 dBA.

4.3.9 DAY JULY 23 Measurements of the point 04

4.3.9.1 Landing of the LET-L410 at the point 04

Time of measurement	Aircraft type	Flight phase	Maximum dbA value	Minimum dbA value
05:54 UTC	LET-L410	Landing	74.5 dbA	45.8 dbA

Table 22: Landing of LET-L410

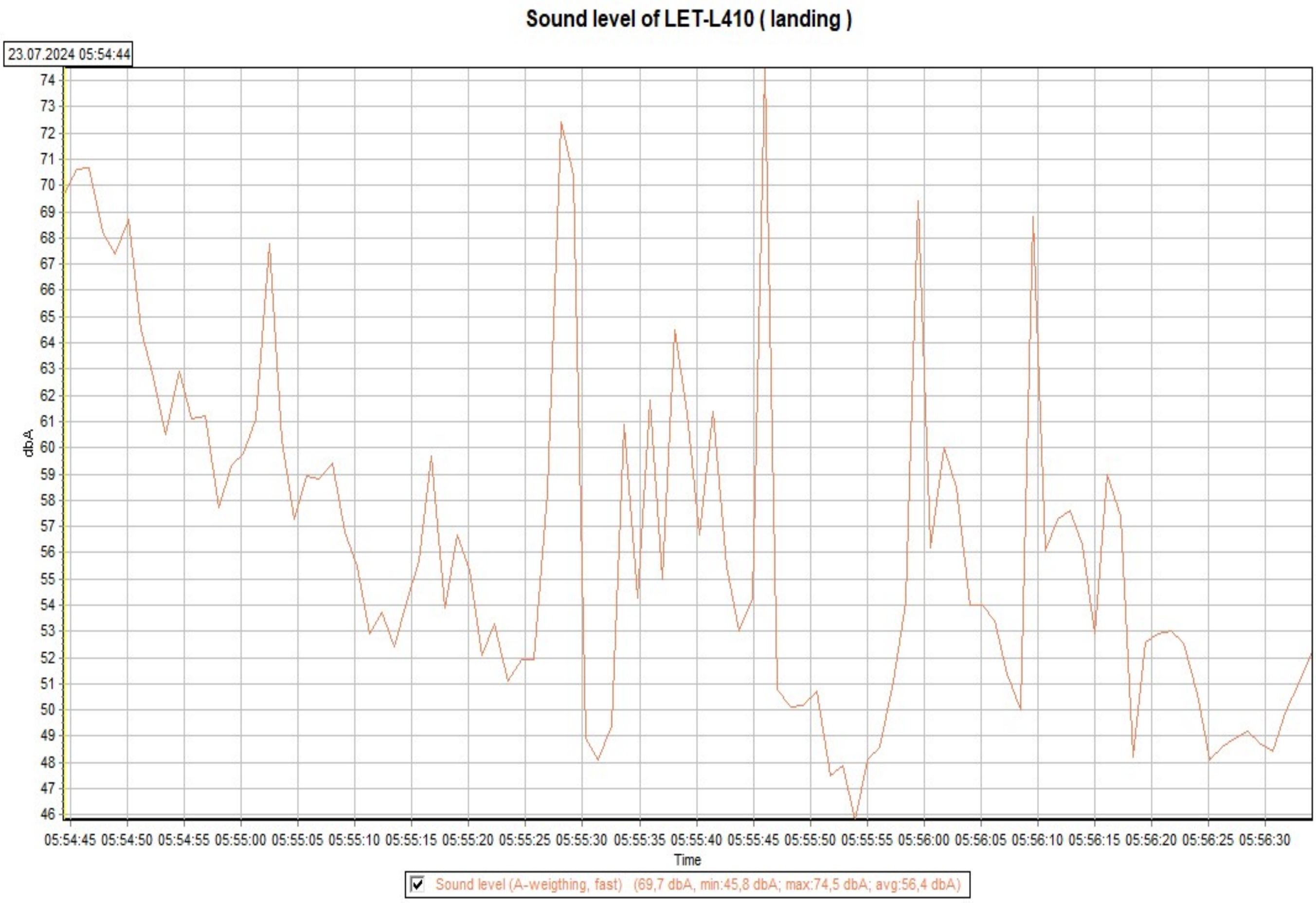

Figure 4-15: Noise measurement result of the Landing of the LET-L410

The figure shows the sound level of a LET-L410 aircraft landing. The graph plots sound level in decibels (dBA) over time. The graph shows that the sound level fluctuates significantly during the landing, reaching a peak of 74.5 dBA and a minimum of 45.8 dBA. The average sound level during the landing is 56.4 dBA.

4.3.9 DAY JULY 23 Measurements of the point 04

4.3.9.2 Landing of the ATR 75 at the point 04

Time of measurement	Aircraft type	Flight phase	Maximum dbA value	Minimum dbA value
06:05 UTC	ATR 75	Landing	75.8 dbA	44.2 dbA

Table 23: Landing of ATR 75

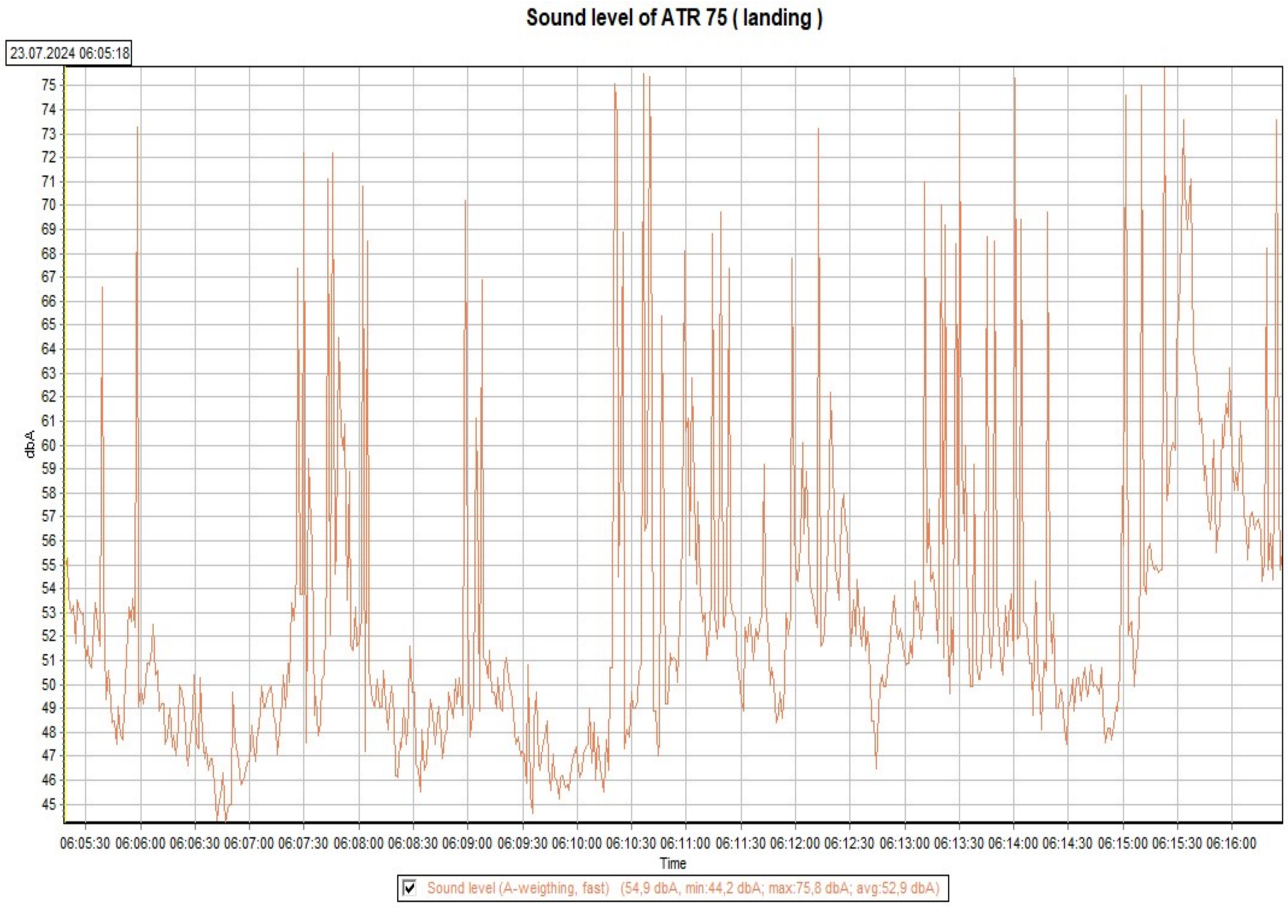

Figure 4-16: Noise measurement result of the Landing of the ATR 75

This figure shows the sound level of an ATR 75 aircraft during landing. The graph plots the sound level in dBA (decibels A-weighted) over time. The aircraft appears to have made a relatively smooth landing, with the sound level peaking at around 75 dBA and then decreasing gradually to around 50 dBA. The average sound level during the landing was 52.9 dBA.

4.3.9 DAY JULY 23 Measurements of the point 4

4.3.9.3 Taxiing and Take-off of the Beechcraft BE1900 at the point 4

Time of measurement	Aircraft type	Flight phase	Maximum dbA value	Minimum dbA value
06:17 UTC	Beechcraft BE1900	Taxiing and Take-off	85.4 dbA	48.9 dbA

Table 24: Taxiing and Take-off of Beechcraft BE1900

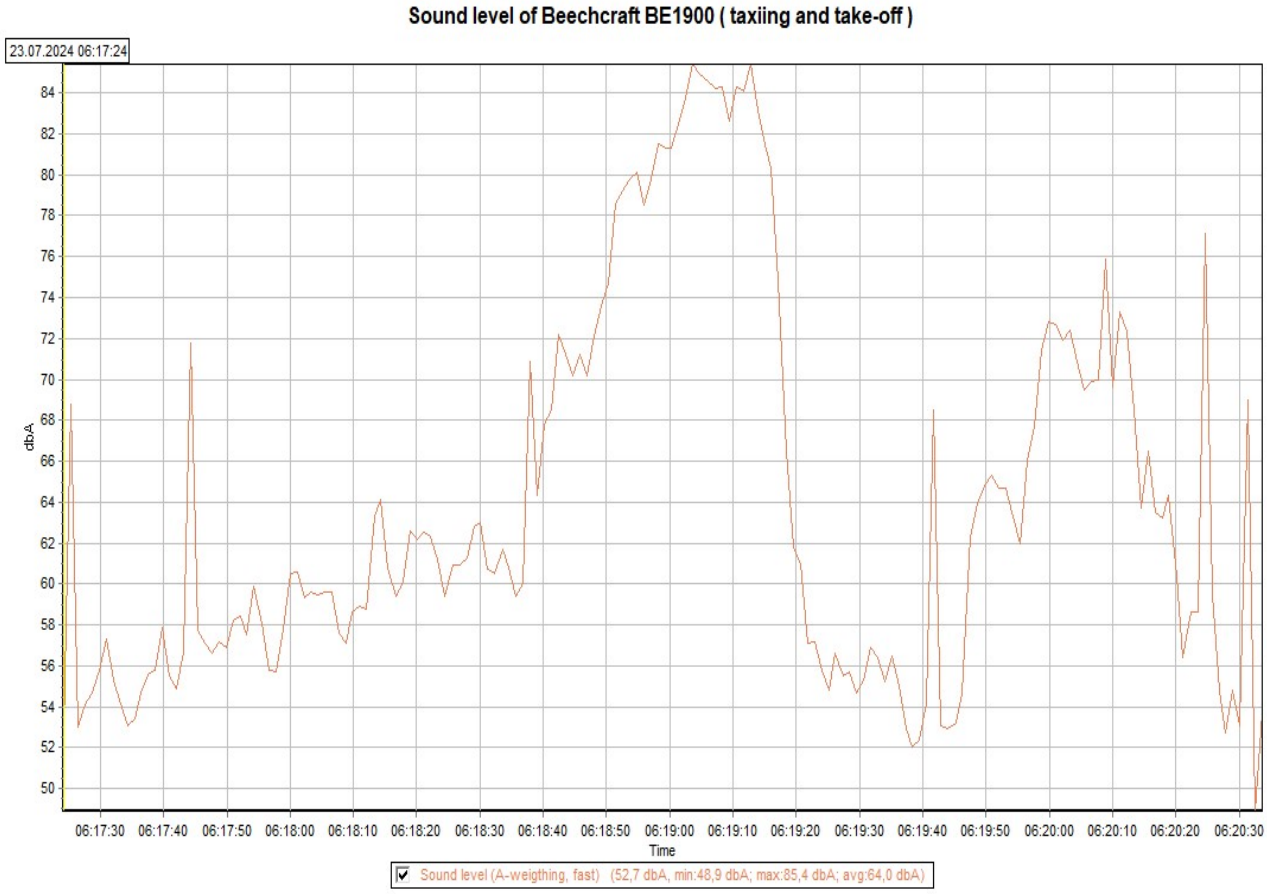

Figure 4-17: Noise measurement result of the Taxiing and Take-off of the Beechcraft 1900

The figure shows a graph of the sound level of a Beechcraft BE1900 during taxiing and take-off. The graph shows that the sound level fluctuates, but is generally higher during take-off. The minimum sound level recorded is 48.9 dBA, the maximum sound level recorded is 85.4 dBA, and the average sound level is 64.0 dBA**.**

4.3.9 DAY JULY 23 Measurements of the point 04

4.3.9.4 Landing of the Beechcraft BE1900 at the point 04

Time of measurement	Aircraft type	Flight phase	Maximum dbA value	Minimum dbA value
06:33 UTC	Beechcraft BE1900	Landing	77.6 dbA	48.2 dbA

Table 25: Landing of Beechcraft BE1900

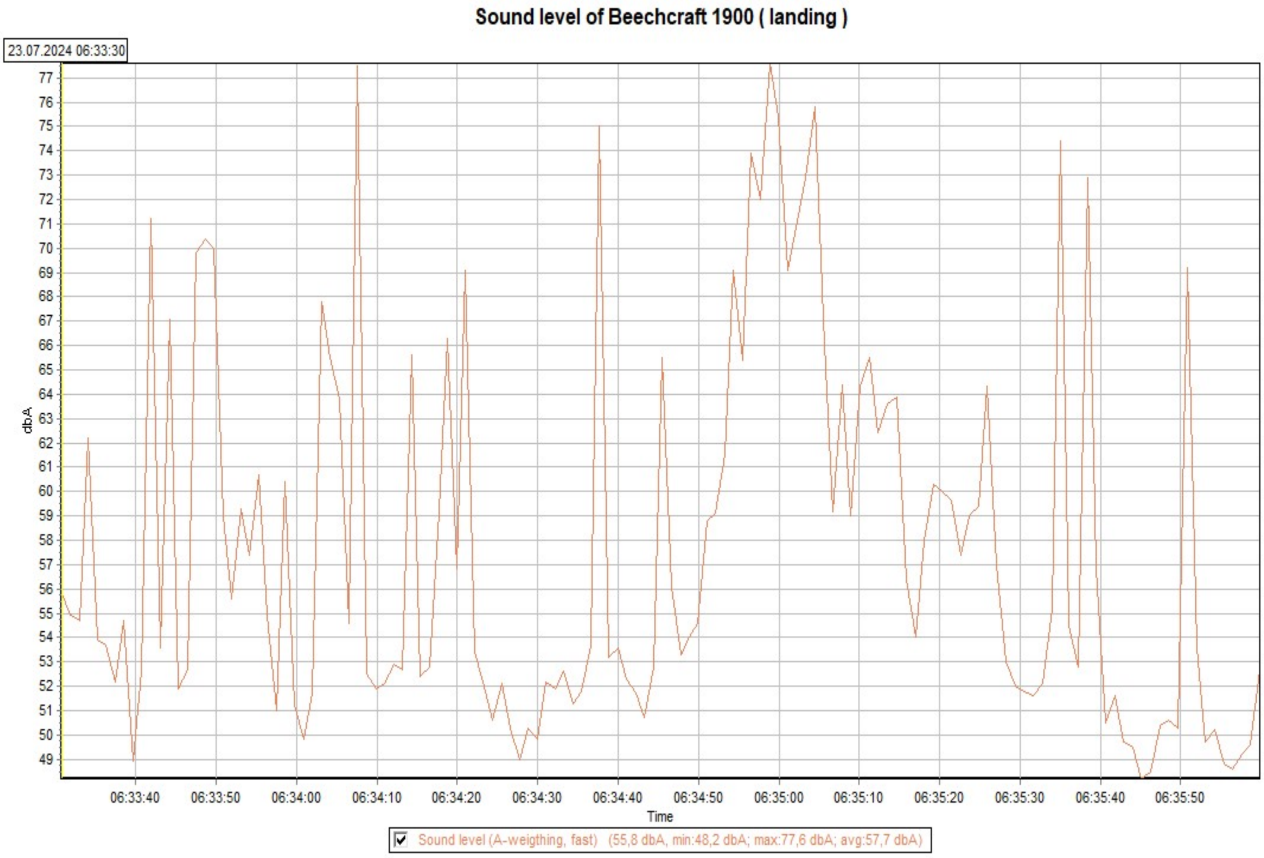

Figure 4-18: Noise measurement result of the Landing of Beechcraft 1900

This graph shows the sound level of a Beechcraft 1900 airplane as it's landing. The data was collected on July 23, 2024, at 6:33:30 am, and it shows the sound levels in decibels (dBA) over time. The graph shows that the sound level fluctuates significantly, with peaks reaching up to 77.6 dBA and troughs reaching as low as 48.2 dBA. The average sound level over the recording period was 57.7 dBA.

4.3.9 DAY JULY 23 Measurements of the point 04

4.3.9.5 Landing of the BOMBARDIER CRJ-200 at the point 04

Time of measurement	Aircraft type	Flight phase	Maximum dbA value	Minimum dbA value
06:41 UTC	CRJ-200	Landing	78.2 dbA	45.3 dbA

Table 26: Landing of CRJ-200

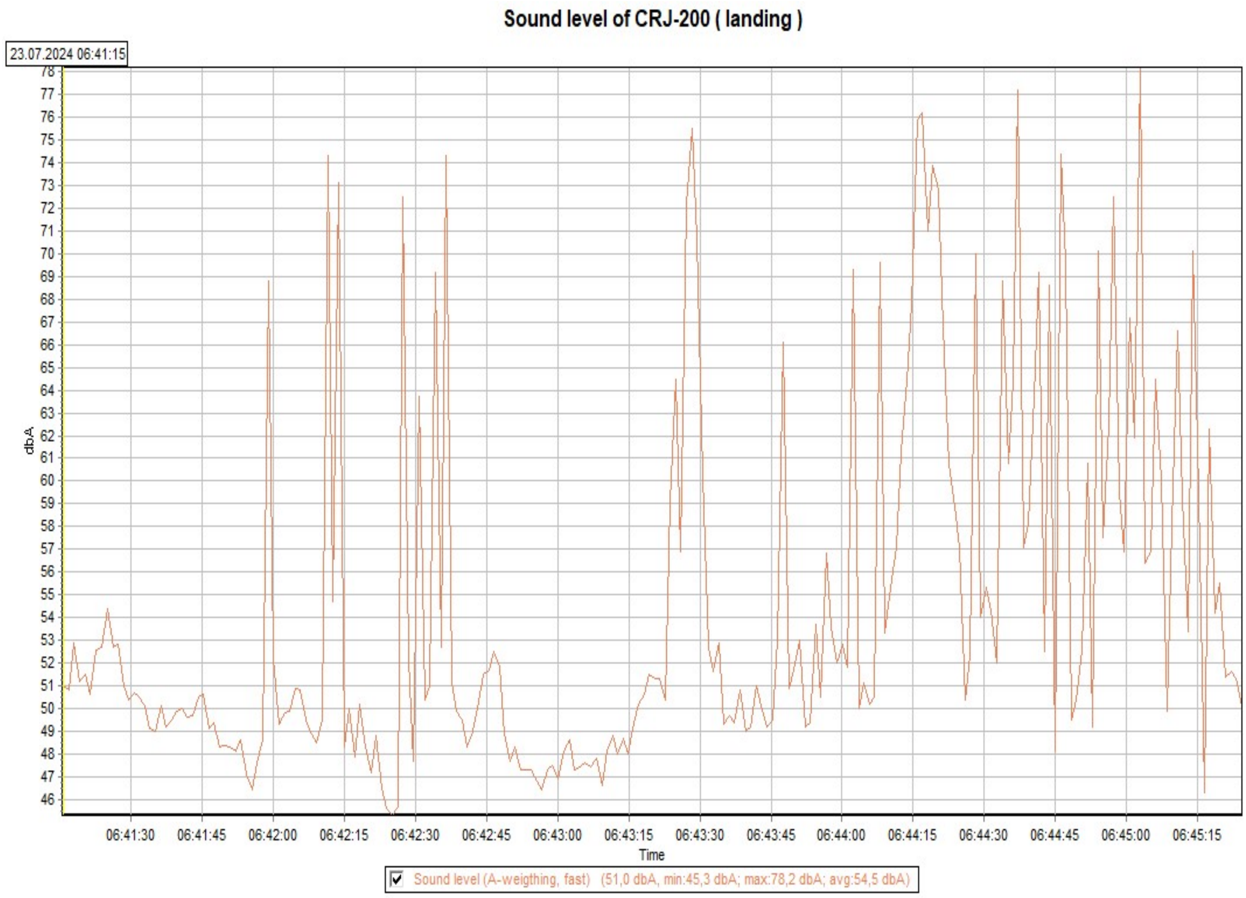

Figure 4-19: Noise measurement result of the Landing of Bombardier CRJ-200

This figure shows a sound level graph of a CRJ-200 airplane landing. The graph shows the sound level in decibels (dBA) over time. The sound level fluctuates, but generally stays between 50 and 60 dBA. The highest sound level is about 78 dBA.

4.3.9 DAY JULY 23 Measurements of the point 4

4.3.9.6 Taxiing and Take-off of the ATR 72 at the point 4

Time of measurement	Aircraft type	Flight phase	Maximum dbA value	Minimum dbA value
06:47 UTC	ATR 72	Taxiing and Take-off	95.4 dbA	49.3 dbA

Table 27: Taxiing and Take-off of ATR 72

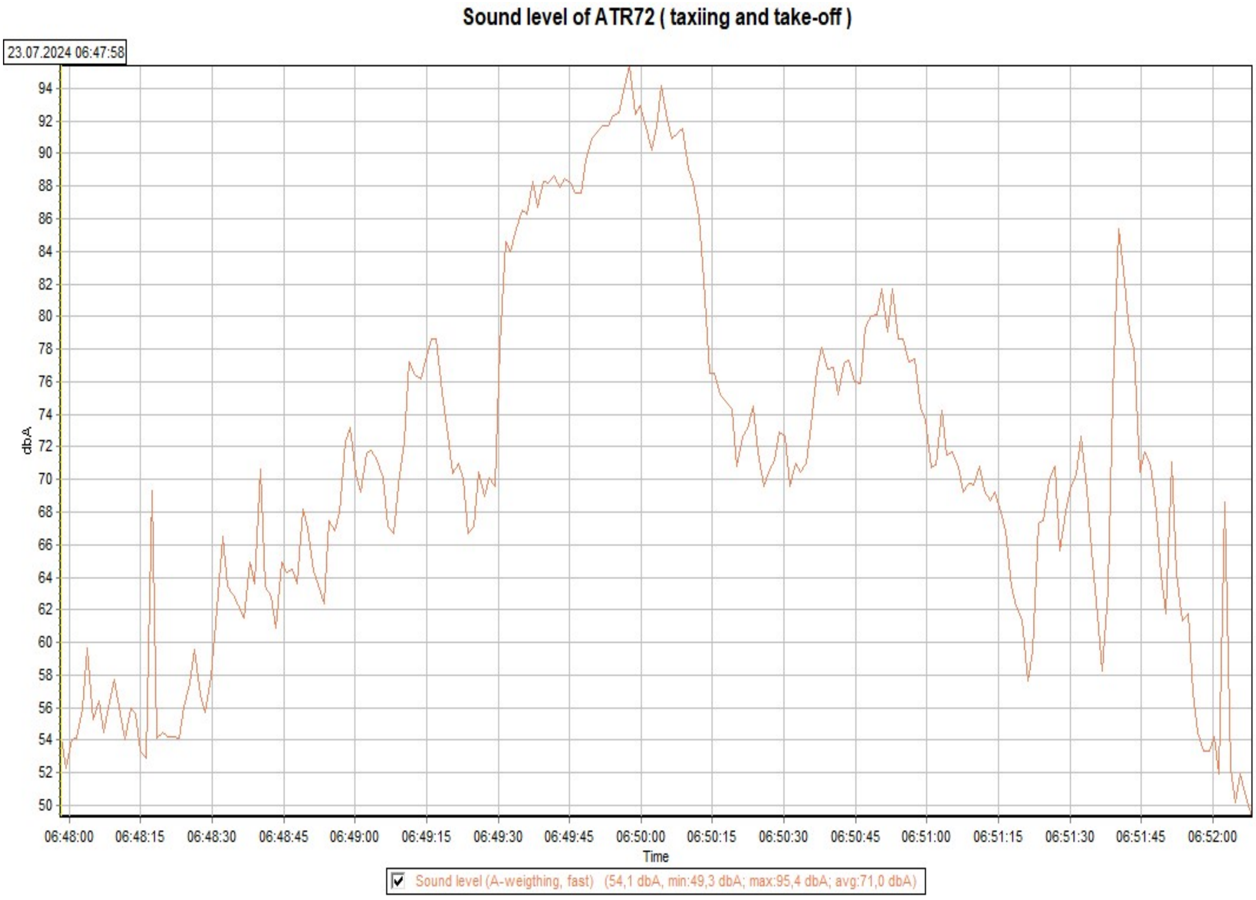

Figure 4-20: Noise measurement result of the Taxiing and Take-off of the ATR 72

The figure shows a graph of sound level in dBA over time. The graph shows the sound level of an ATR72 aircraft during taxiing and take-off. The sound level fluctuates over time, but generally increases as the aircraft prepares for take-off. The highest sound level recorded was 95.4 dBA, and the average sound level was 71.0 dBA. It is clear that the aircraft is making a lot of noise, particularly during takeoff.

4.3.9 DAY JULY 23 Measurements of the point 4

4.3.9.7 Landing of the LET-L410 at the point 4

Time of measurement	Aircraft type	Flight phase	Maximum dbA value	Minimum dbA value
06:55 UTC	LET-L410	Landing	75.0 dbA	47.2 dbA

Table 28: Landing of LET-L410

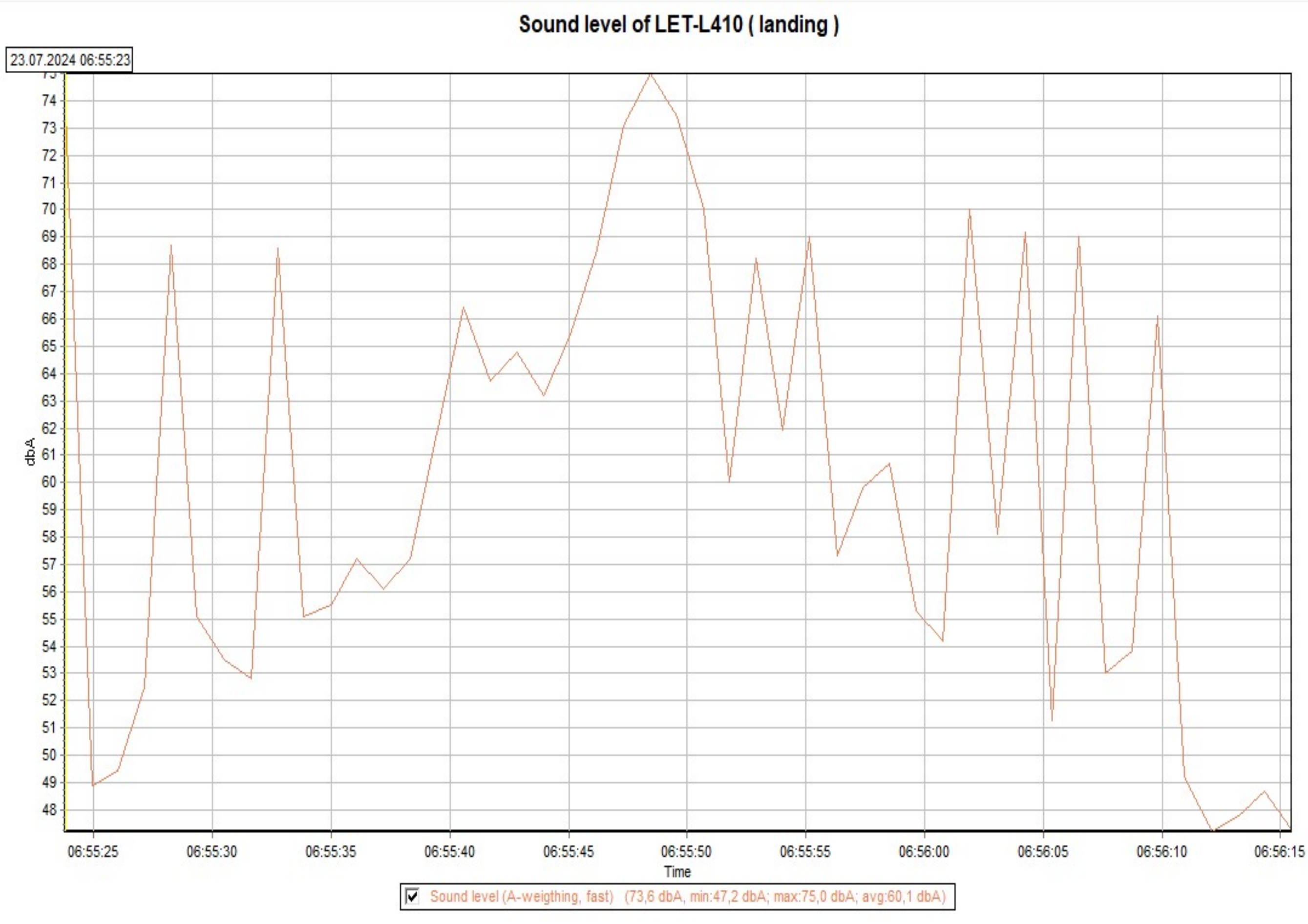

Figure 4-21: Noise measurement result of the Landing of LET-L410

This is a graph showing the sound level of a LET-L410 aircraft during landing. The graph shows that the sound level fluctuated between 47.2 dbA and 75.0 dbA, with an average of 60.1 dbA. The sound level was highest around 06:55:47, when the aircraft was likely at its lowest altitude.

4.3.10 DAY JULY 23 Measurements of the point 2

4.3.10.1 Taxiing and Take-off of the Beechcraft BE1900 at the point 2

Time of measurement	Aircraft type	Flight phase	Maximum dbA value	Minimum dbA value
07:16 UTC	Beechcraft BE1900	Taxiing and Take-off	89.1 dbA	52.8 dbA

Table 29: Taxiing and Take-off of Beechcraft BE1900

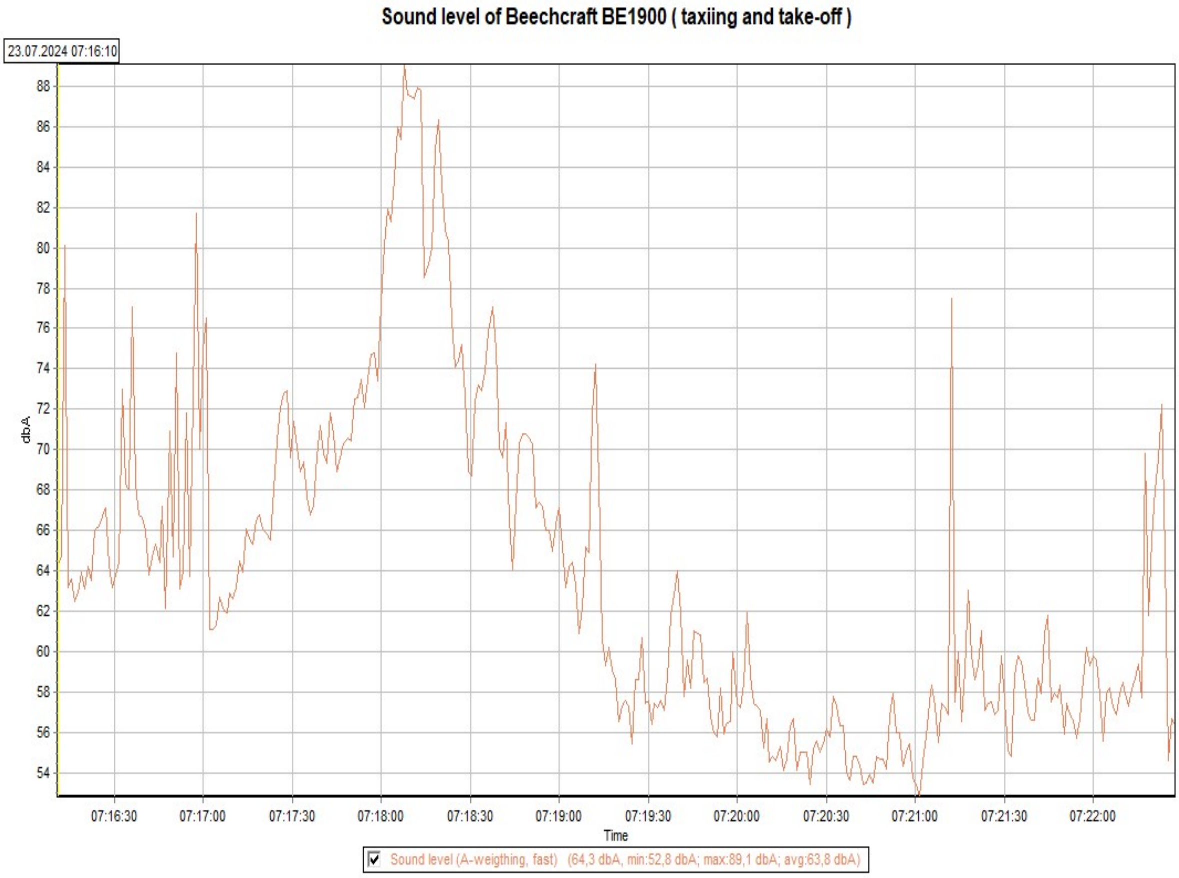

Figure 4-22: Noise measurement result of the Taxiing and Take-off of Beechcraft 1900

The figure shows a graph of the sound level of a Beechcraft BE1900 airplane during taxiing and take-off. The graph shows that the sound level fluctuates, with peaks at certain points. This is likely due to the engine noise as the plane taxies and takes off. The average sound level is 63.8 dBA, with a minimum of 52.8 dBA and a maximum of 89.1 dBA.

4.3.10 DAY JULY 23 Measurements of the point 2

4.3.10.2 Taxiing of the Beechcraft BE1900 at the point 2

Time of measurement	Aircraft type	Flight phase	Maximum dbA value	Minimum dbA value
07:23 UTC	Beechcraft BE1900	Taxiing	78.7 dbA	52.8 dbA

Table 30: Taxiing of Beechcraft BE1900

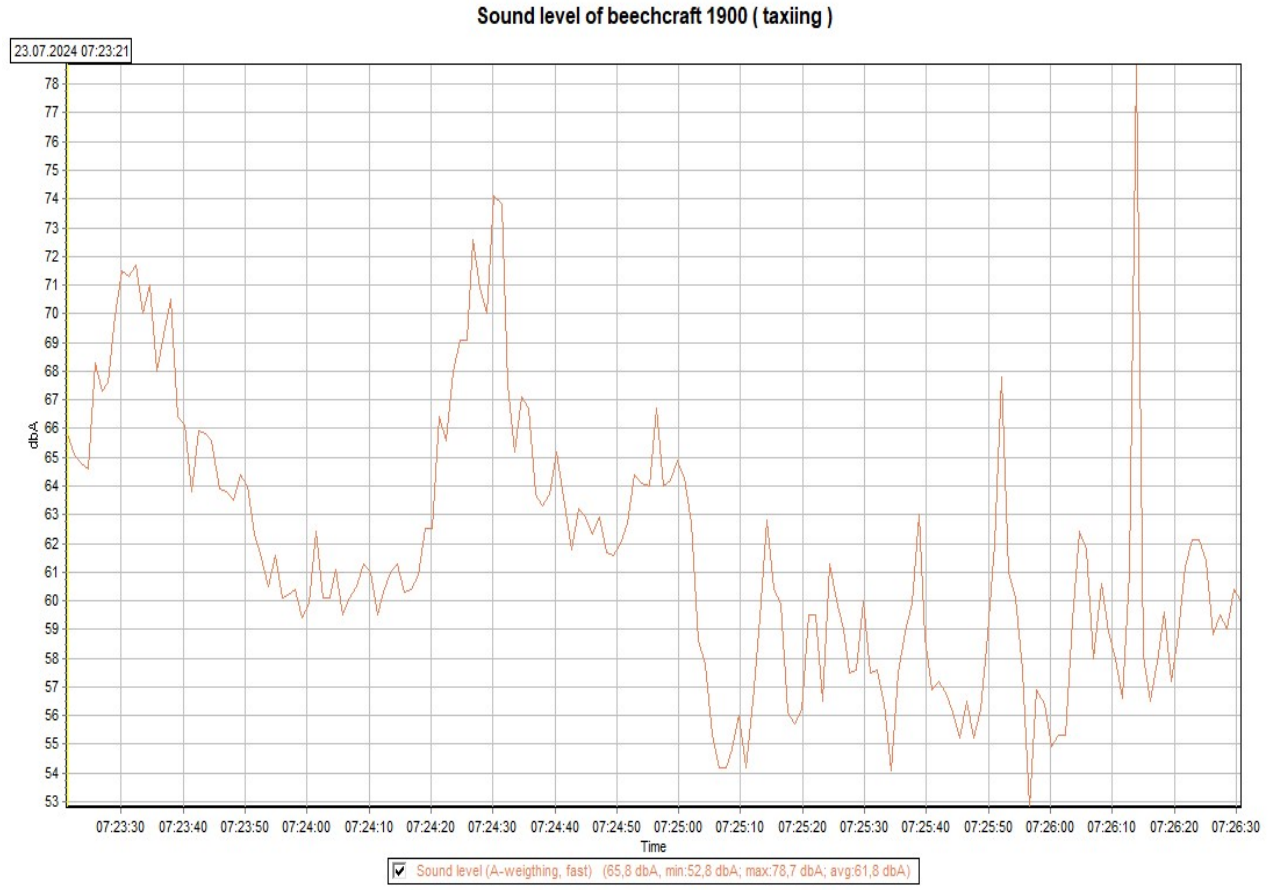

Figure 4-23: Noise measurement result of the Taxiing of Beechcraft 1900

The figure shows a graph of sound level over time. The graph shows the sound level of a Beechcraft 1900 aircraft taxiing. The sound level fluctuates, but the maximum level is around 78 dBA, the minimum level is around 53 dBA, and the average sound level is around 61 dBA.

4.3.10 DAY JULY 23 Measurements of the point 02

4.3.10.3 Taxiing of the Cessna 560XL at the point 02

Time of measurement	Aircraft type	Flight phase	Maximum dbA value	Minimum dbA value
07:40 UTC	Cessna 560XL	Taxiing	91.9 dbA	48.3 dbA

Table 31: Taxiing of Cessna 560XL

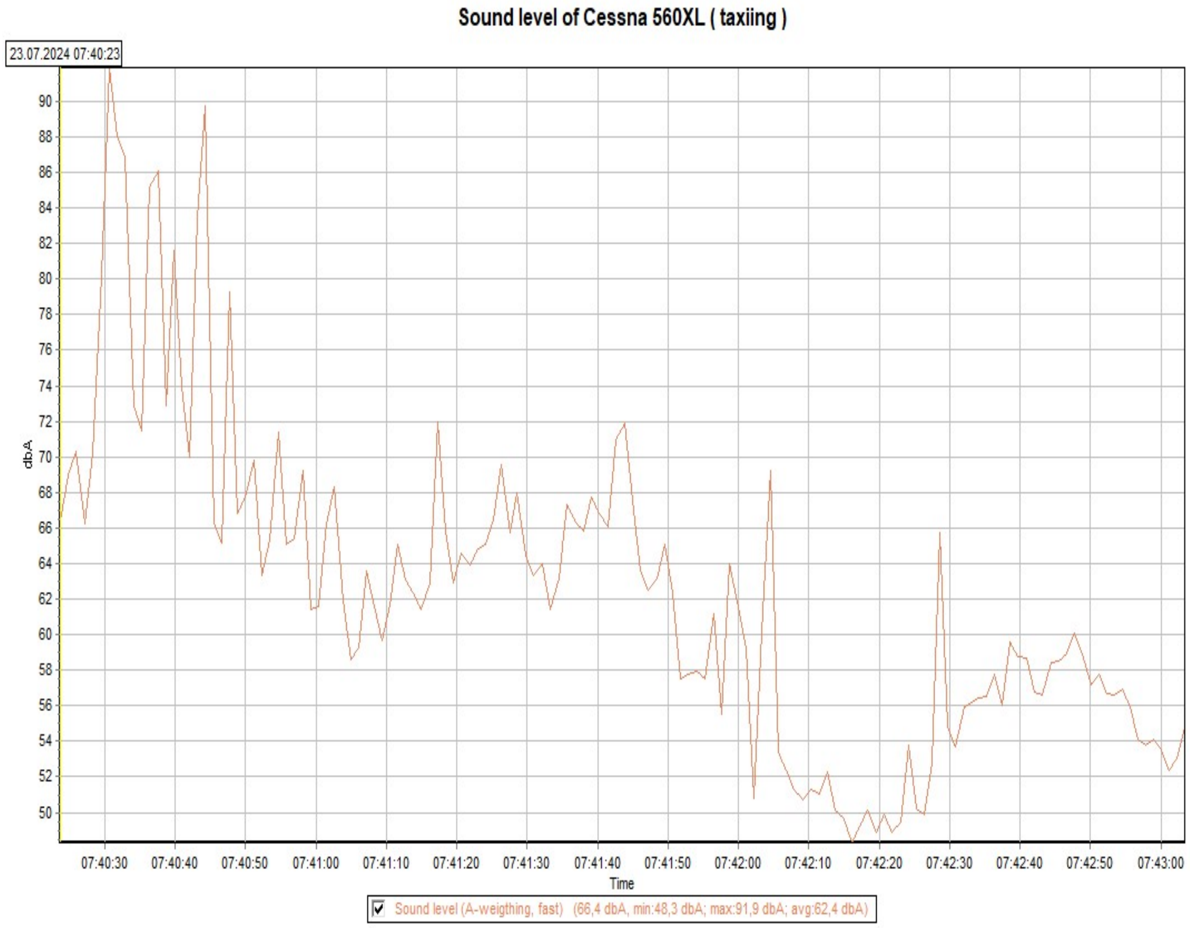

Figure 4-24: Noise measurement result of the Taxiing of Cessna 560XL

The figure shows a graph of sound level over time, recorded during the taxiing of a Cessna 560XL aircraft. The sound level fluctuates between 48.3 dBA and 91.9 dBA, with an average of 62.4 dBA. The measurement was taken on July 23rd, 2024, starting at 07:40:23.

4.3.10 DAY JULY 23 Measurements of the point 2

4.3.10.4 Taxiing of the Boing 733-800 and the Take-off of the Cessna 560XL at the point 2

Time of measurement	Aircraft type	Flight phase	Maximum dbA value	Minimum dbA value
07:44 UTC	Boeing 737-800	Taxiing	82.1 dbA	48.1 dbA
	Cessna 560XL	Take-off		

Table 32: Taxiing of Boeing 737-800 and Take-off of Cessna 560XL

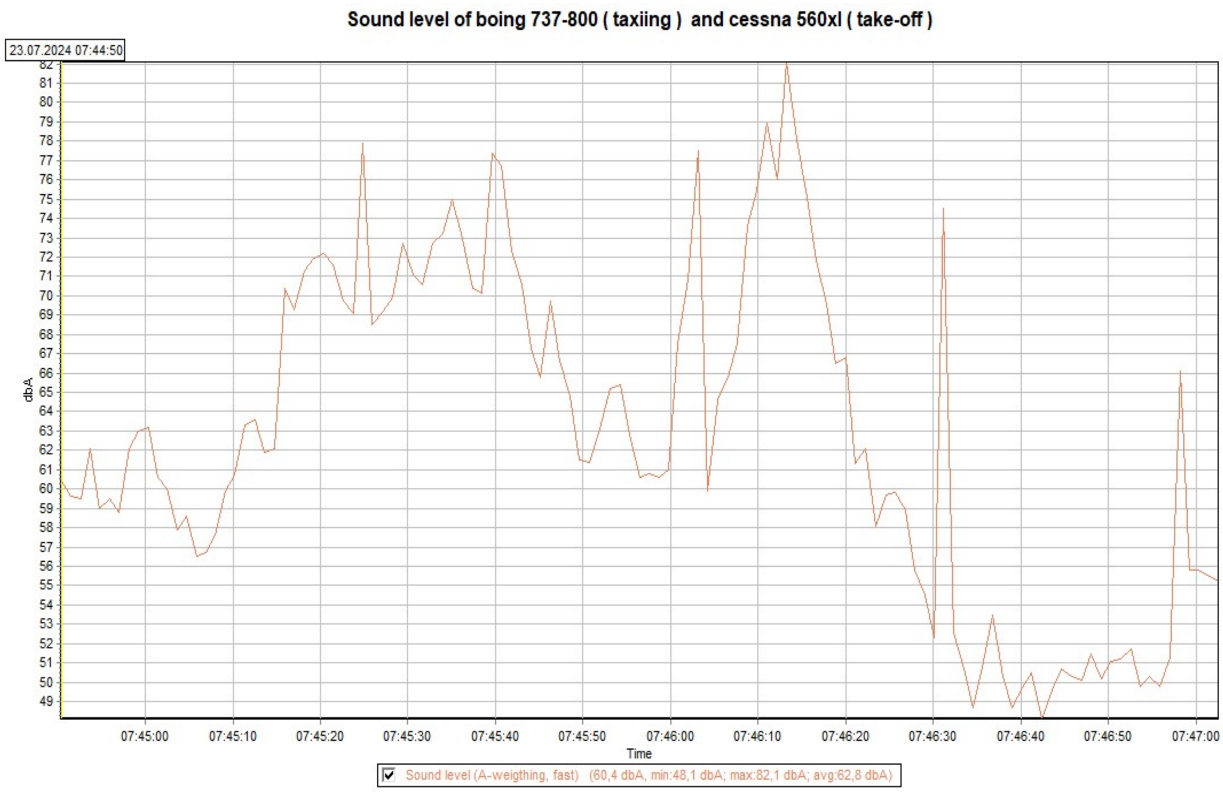

Figure 4-25: Noise measurement result of Taxiing of Boeing 737-800 and Take-off of Cessna 560XL

The figure shows a graph of sound levels over time. The sound levels are likely from a Boeing 737-800 taxiing and a Cessna 560xl taking off.

The graph shows that the sound level of the Boeing 737-800 taxiing was relatively consistent, fluctuating between 60 and 70 dBA. The sound level of the Cessna 560xl taking off was much higher, reaching a peak of 82.1 dBA.

4.3.10 Measurements of the point 2

4.3.10.5 Startup and Taxiing of the LET-L410 at the point 2

Time of measurement	Aircraft type	Flight phase	Maximum dbA value	Minimum dbA value
08:25 UTC	LET-L410	Startup and Taxiing	87.9 dbA	41.5 dbA

Table 33: Startup and Taxiing of LET-L410

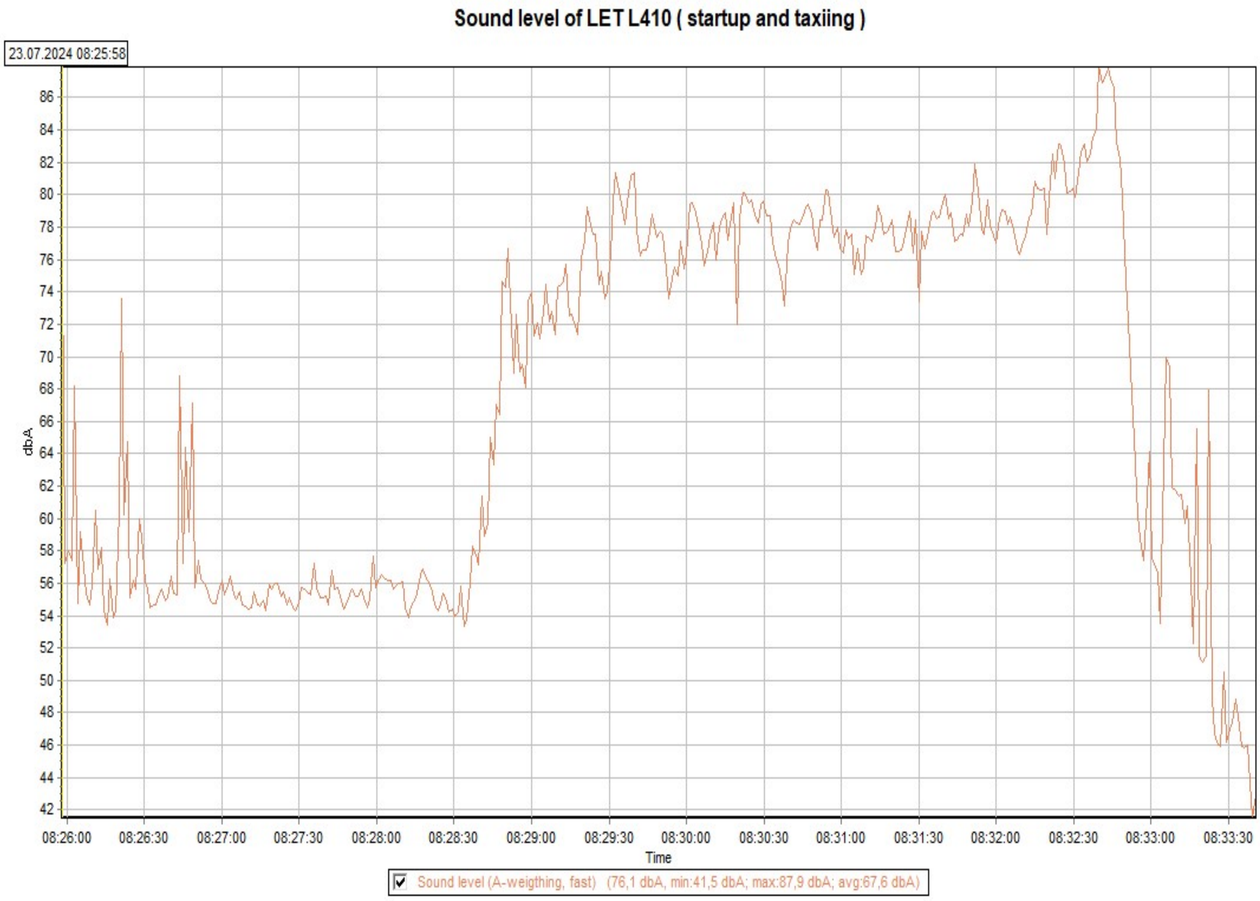

Figure 4-26: Noise measurement result of the Startup and Taxiing of LET-L410

This is a graph of the sound level of a LET L410 aircraft during startup and taxiing. The graph shows that the sound level increases during startup and then decreases as the aircraft taxis. The maximum sound level is 87.9 dbA and the average sound level is 67.6 dBA. The minimum sound level is 41.5 dba. The graph also shows that the sound level fluctuates significantly during the startup and taxiing phases.

4.3.10 DAY JULY 23 Measurements of the point 2

4.3.10.6 Startup of the Cessna 208B at the point 2

Time of measurement	Aircraft type	Flight phase	Maximum dbA value	Minimum dbA value
08:01 UTC	Cessna 208B	Startup	74.2 dbA	48.9 dbA

table 34: Startup of Cessna 208B

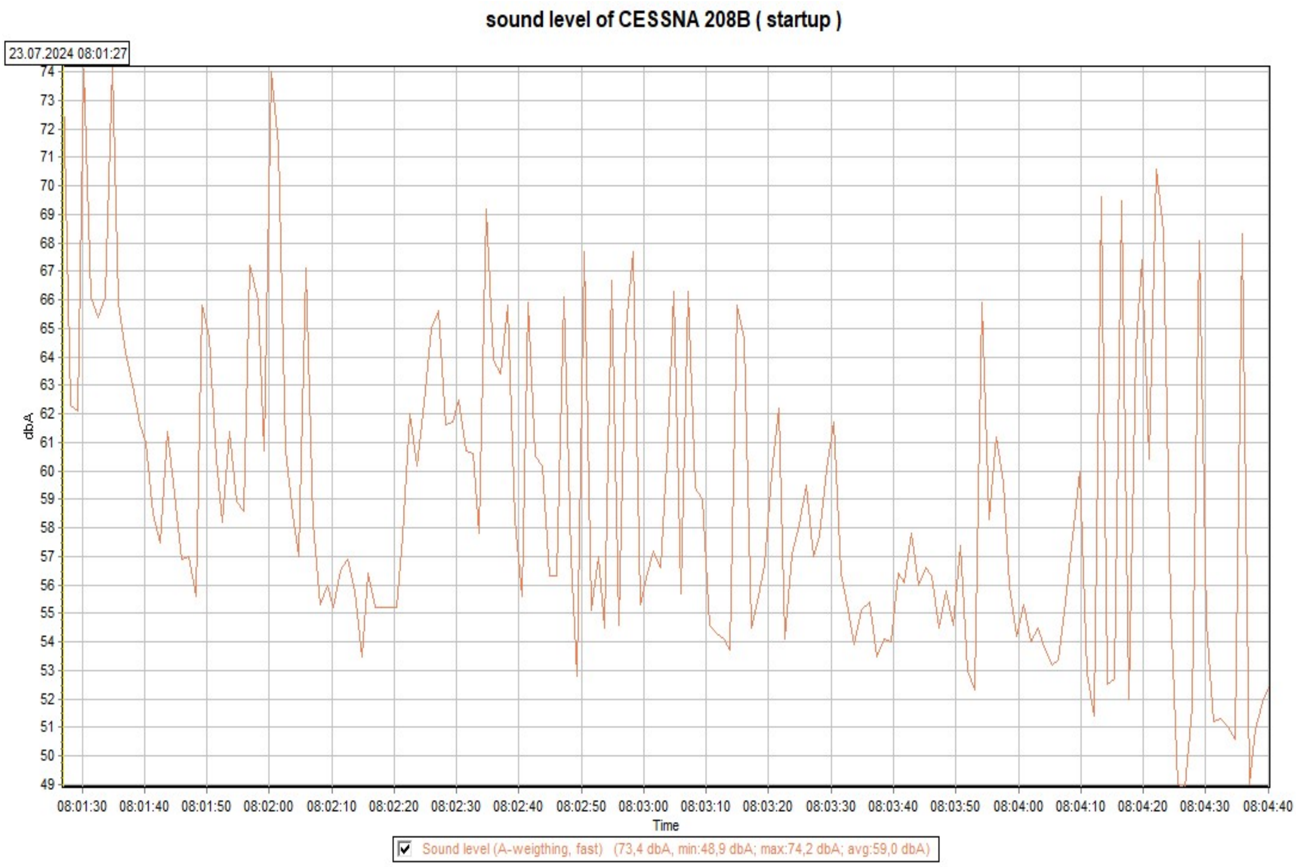

Figure 4-27: Noise measurement result of the Startup of Cessna 208B

This is a graph showing the sound level of a Cessna 208B airplane during startup. The sound level is measured in decibels (dBA) and the time is shown on the x-axis. The graph shows that the sound level peaks at around 74 dBA, then decreases gradually, and remains stable around 55 dBA.

4.3.10 DAY JULY 23 Measurements of the point 2

4.3.10.7 Startup of the DHC-6 at the point 2

Time of measurement	Aircraft type	Flight phase	Maximum dbA value	Minimum dbA value
08:46 UTC	DHC6	Startup	89.8 dbA	48.6 dbA

Table 35: Startup of DHC6

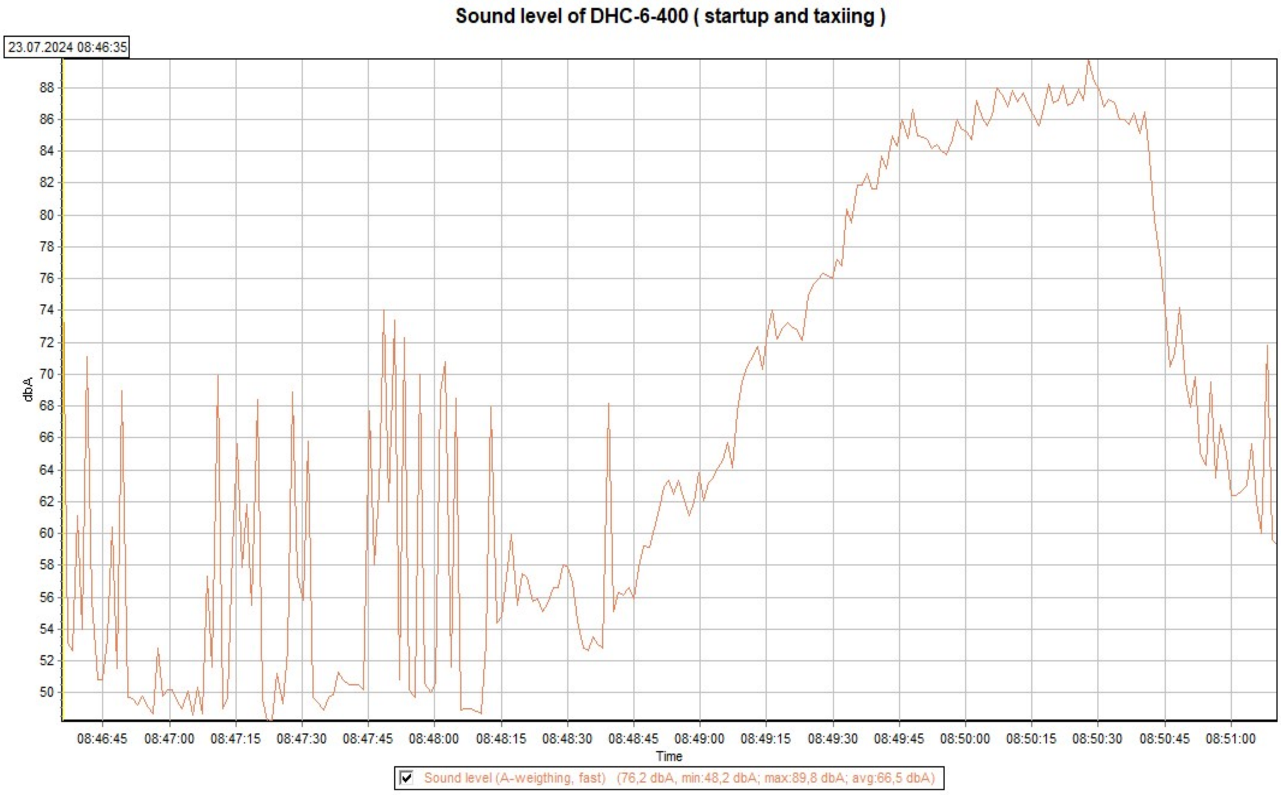

Figure 4-28: Noise measurement result of the Starup of the DHC6

This graph shows the sound level of a DHC-6-400 aircraft during startup and taxiing. The sound level is measured in dbA (decibels A-weighted) and is plotted against time. The graph shows that the sound level starts at about 50 dbA and gradually increases to about 89 dbA. The sound level then drops off slightly before reaching a plateau of about 85 dbA. The average sound level during this period is 66.5 dbA.

Based on this graph, we can see that the DHC-6-400 aircraft produces a significant amount of noise during startup and taxiing. This is likely due to the engine running at high power levels during these phases of flight. The sound level is also quite variable, with peaks and troughs occurring throughout the graph. This is likely due to the changing engine speed and load during these phases of flight.

4.4 Discussion of noise measurement results

Aircraft generate noise disturbances that can significantly impair workers' abilities and also disrupt the lives of nearby residents. The WHO recommends a maximum acceptable noise exposure level of 80 dB over an 8-hour workday. If the noise level is too high (exceeding 130 dB), any exposure, even for a very short duration, is hazardous. The results of the noise measurements and the assessment of regulatory compliance are summarized in the table below:

Period of measurement				
Points	**Aircraft type**	**dBmin(A)**	**dBmax(A)**	**Maximum acceptable threshold**
01	**ATR 72**	**66.1**	**94.5**	**80dB(A)**
	Boing 737-800	**70.9**	**92.1**	
	BE1900	**41.5**	**91.4**	
	DH8D	**45.1**	**94.4**	
02	**PILATUS**	**32.4**	**84.0**	
	DHC6	**55.0**	**93.8**	
	BE1900	**52.8**	**89.1**	
	Cessna 208B	**48.9**	**74.2**	
	LET L410	**41.5**	**87.9**	
03	**Boing 737-800**	**58.0**	**97.6**	
	DHC and DH8B	**47.5**	**86.4**	
04	**CRJ-1000**	**42.8**	**87.4**	
	LET-L410	**45.8**	**74.5**	
	BE1900	**48.9**	**85.4**	
	ATR 72	**49.3**	**95.4**	
	ATR 75	**44.2**	**75.8**	
05	**DH8D**	**53.7**	**91.2**	
	CESSNA 560XL	**53.1**	**89.1**	
	ATR 72	**46.6**	**93.1**	

Table 36:The results of the measurement in all the points

We can see that the aircraft with the highest noise level are the ATR 72 and Boeing 737-800 with over than 95 dbA, this is concerning as we know that when the aircraft reach this level of noise for just a couple of minutes and that's not dangerous as much as reaching 130 dbA even for seconds, but in the case of Boeing 737-800 and Beechcraft BE1900 who do a lot of flights on this airport more than all other aircrafts its most likely that the workers will be in dangerous for get exposed for it especially in Tuesday and Wednesday when the traffic reach it max, in average 20 flights per day and that make it at least 1 hour of being exposed for +90 dbA from the Boeing 737-800 alone, the same goes for the Beechcraft BE1900 which make it hard to say that it's a safe environment for the workers especially the ones who don't wear ears protections

With regard to the noise emission thresholds prescribed in Annex 16 of the ICAO and the WHO regulations, our measurements at all points do not comply with the regulations entirely. However, it's not that black and white on this matter we can see that by the increase of the air traffic it will be a huge problem for the workers to deal with it

We should not forget that in some cases, it is challenging to determine the impulsive nature of the noise emitted by aircraft, particularly due to occasional sound events that may occur, as well as interfering noises (such as trucks or cars passing by), which can be frequent and disrupt the analysis.

4.5 Conclusion

The noise pollution study at Hassi Messaoud Airport reveals that the noise levels generated by the airport's operations, particularly from aircraft takeoffs and landings, are significant but generally within the limits set by national and international noise standards in most cases but there's occasions when it surpasses it and might be dangerous for the workers who were exposed to it. However, areas closest to the airport, including some residential zones, experience higher noise levels that occasionally exceed recommended thresholds, potentially leading to disturbances for local inhabitants.

For this year, Hassi Messaoud / Oued Irara–Krim Belkacem Airport has demonstrated compliance with the essential aeronautical certification standards for both aircraft operations and the existing levels of air traffic. One of the key factors that contributes to the airport's favorable assessment in terms of noise pollution is its relatively isolated location, situated far from densely populated areas. This geographical advantage plays a crucial role in minimizing the negative impact of noise generated by aircraft, particularly during takeoff and landing phases, which are known to produce the highest levels of sound.

General conclusion

This study provides a comprehensive analysis of noise pollution at Hassi Messaoud / Oued Irara–Krim Belkacem Airport, offering a detailed assessment of the acoustic environment and its impact on both airport employees and the surrounding community. The investigation involved systematic noise measurements across various airport zones, including runways, taxiways, terminals, and maintenance areas.

The results reveal that while noise levels from aircraft operations particularly during takeoffs and landings are considerable, they generally adhere to the permissible limits set by national and international standards. However, certain areas, notably those in close proximity to active aircraft operations and ground handling activities, frequently exhibit noise levels that exceed recommended exposure thresholds. For instance, noise levels during takeoff can reach up to 97.6 dBA, surpassing the guidelines established by numerous regulatory frameworks. This issue is notably prevalent with specific aircraft models, including the Boeing 737-800, ATR 72, and Beechcraft BE1900 who were the most used aircrafts in this airport, which generate higher noise levels compared to other aircraft.

In response to these results, several noise control measures are recommended installation of Sound Barriers and Acoustic Insulation to be implemented in critical areas near the runway and ground handling zones. And adoption of Quieter Ground Support Equipment to reduce noise during ground operations, enforcement of Stricter Operational Procedures to mitigate noise emissions, especially during peak operational hours. Provision of Personal Protective Equipment (PPE) for employees, such as noise-canceling headphones, to protect against prolonged noise exposure.

Until this year, Hassi Messaoud Airport meets the aeronautical certification requirements and complies with current air traffic operations standards. The airport's location, characterized by a minimal surrounding population, results in relatively minor noise pollution concerns compared to more densely populated urban airports.

In conclusion, Hassi Messaoud Airport is integral to the regional economic and logistical framework. Despite generally adhering to established noise standards, the study highlights specific areas where noise levels particularly from larger aircraft such as the Boeing 737-800, ATR 72, and Beechcraft BE1900 occasionally exceed acceptable limits (yes other types of aircrafts exceed it too but for rare occasions and they aren’t as much as the number of the previous types in the number of flights per day). Preparing for potential future increases in traffic, which could intensify existing noise issues, is crucial. Implementing the recommended noise control measures will be essential in ensuring continued compliance with noise regulations and mitigating impacts on both employees and nearby residents.

Bibliography

1. Master 01 Course (2022/2023): Noise and Environments at the Institute of Aeronautics and Space Studies in Blida by Mr. Rezoug Tahar

2. Annex 16 : the Convention on International Civil Aviation - Environnemental Protection, Volume 1 : Aircraft Noise.

3. Senate Public Works Committee, Noise Pollution and Abatement Act of 1972, S. Rep. No. 1160, 92nd Cong. 2nd

4. Mrs. Daoudi Sarra and Mrs. Djebbabi Nour Hane "Preliminary study of noise pollution at the level of Algiers airport." Thesis for the Master's Degree in Aeronautics, Specialization: Air Operations (2021).

5. article of " aircraft noise assessment , prediction and control " https://gat04-live-1517c8a4486c41609369c68f30c8-aa81074.divio-media.org/filer_public/86/64/866446fe-8118-4565-98e2-d46b735ffac7/cd2064.pdf

6. website of session BYJU'S "Effects of Noise Pollution" « https://byjus.com/biology/effects-of-noise-pollution/».

7. article of "ACOUSTICS & NOISE OF FLIGHT VEHICLES" https://eaglepubs.erau.edu/introductiontoaerospaceflightvehicles/chapter/noise-of-flight-vehicles/

8. article of "Aircraft Airframe Noise - Research Overview (Andrew Faszer)" https://web.archive.org/web/20080517104120/http://www2.eng.cam.ac.uk/~acf40/research_ov.htm

9. Website of TAF-METAR "Hassi Messaoud-Oued Irara Krim Belkacem Airport" https://metar-taf.com/fr/airport/DAUH-hassi-messaoud-oued-irara-krim-belkacem-airport

10. Website of Iberdrola "Noise pollution" « https://www.iberdrola.com/sustainability/what-is-noise-pollution-causes-effects-solutions ».

11. Website of Québec "Noise measurement" https://www.quebec.ca/en/health/advice-and-prevention/health-and-environment/the-effects-of-environmental-noise-on-health/noise-measurement

12. article from "flyquietoak.com" titled "Aircraft Noise" https://flyquietoak.com/wp-content/uploads/2022/04/aircraft_noise_fundamentals.pdf