Factors Affecting Aircraft Noise

Summary Report

LONDON GATWICK NOISE MANAGEMENT BOARD | Programme Steering Group

November 2025

The information provided in this report specifically refers to the London Gatwick NMB, and should strictly not be re-purposed, taken out of context, or misused.

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Foreword

This report is the result of a project need identified by London Gatwick's Noise Management Board. The report compiles extensive research into those factors that impact aircraft noise on the ground, creating varying soundscapes under varying conditions.

The information forming this report will ultimately form a table from which the information will be easily accessible and will act as a central repository for information that will help stakeholders understand more about the fluctuations in aircraft noise on the ground that they may be experiencing; or simply for those interested in understanding more about the acoustical influences and variables of an aircraft in flight.

It is worth noting that this report is not exhaustive, of content areas or factors. Once built, the table will remain a living, evolving document, with new factors being added as they are identified.

Readers may wish to first familiarise themselves with the definitions page before beginning the report, to help navigate some of the more technical language; overall, we have worked to produce a report that is as simplified as it can be for all to understand.

We hope you find this report insightful. For any queries following your reading of the report, please contact GatwickNMB.UK@egis-group.com

Dr Rebecca Mian | Noise Management Programme Manager

Charlotte Smerdon, Joseph Branagan | Egis Programme Steering Group team

A Note on Noise vs Sound

Throughout this report, the word ‘noise’ is used repeatedly. It should be understood that the definition of noise is ‘unwanted sound’. Therefore, in the majority of cases that the word noise is used throughout the report, it is representative of the core reasons for this research, and reflective of the audience it has primarily been developed for. Where ‘sound’ has been used, it is because ‘noise’ can scientifically not be a synonym.

It is for this reason that we often talk about ‘aircraft noise on the ground’; people experiencing aircraft noise, will only experience it at ground level, whereas any ‘noise’ promulgating from an aircraft in flight, for whatever reason, can only be known (acoustically) as sound.

Factors Affecting Aircraft Noise

Content

- Aircraft Noise at Source
- Impact of the Environment
- Operational Impacts

Definitions

Noise Measurements

- **dB | Decibel:** unit that measures sound level on a logarithmic scale, where each 10 dB increase means the sound is approximately twice as loud.
- **$L_{A\ MAX}$ | Level Above:** A-weighted scale referring to the maximum sound level recorded of an event such as the overflight of an aircraft.
- **SEL | Single Event Level:** the energy of the sound wave of the entire period being compressed into a 1-second reference period measured in dBA.*
- **EPNL | Effective Perceived Noise Level:** a noise metric developed to better reflect the human perception of aircraft noise, sometimes seen as EPNdb.

Sources of Noise

- **Mechanical:** noise generated by moving components, dominated by engine noise.
- **Aerodynamic:** noise generated by air flowing over the aircraft and its devices (e.g. landing gear, flaps and speedbrakes).

Operational Terms

- **SOP:** Standard Operating Procedures – developed by aircraft manufacturers and airlines to instruct flight crew on carrying routine and non routine tasks**.

Weather Factors

- **Meteorological Conditions**: the current weather state of the environment (including the temperature, humidity, precipitation (rain), wind and atmospheric pressure).
- **Atmospheric Absorption**: sound waves (energy) being converted to heat as they travel through the air, causing the sound to lose intensity and attenuate, leading to quieter sounds on the ground.
- **Shadow Zone:** an area where sound is reduced due to an obstruction or changes in the meteorological conditions.

* In most cases, SEL values are numerically greater than LAmax by an average of 10dB due to aircraft noise events being greater than the 1-second reference period.

** SOPs can vary by both aircraft type and operator (airline)

Aircraft Noise at Source

Engine noise

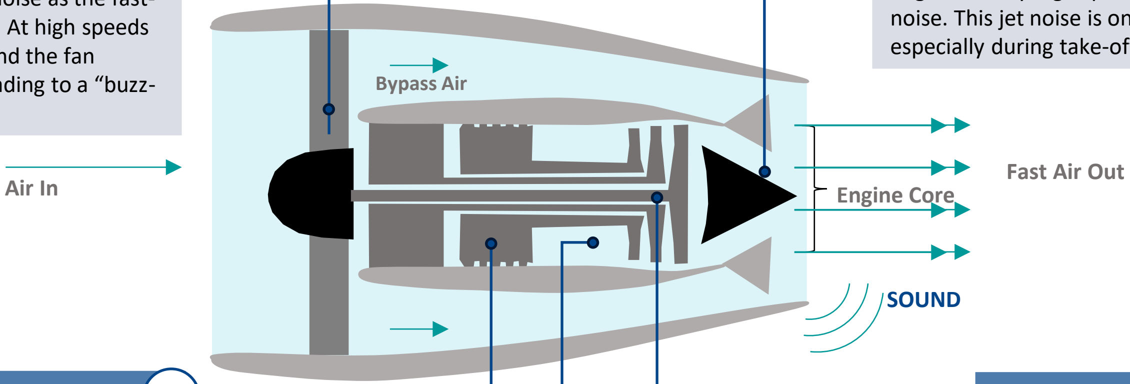
The most significant source of noise is the engine (**mechanical noise**), particularly during take-off and climb. This is due to high-speed airflow passing through the components of the engine, and expulsion of the exhaust gases.

Fan 1

This is the large spinning part at the front of the engine that pulls in air. It creates noise as the fast-moving blades cut through the air. At high speeds (such as take-off) the airflow around the fan blades can become supersonic, leading to a "buzz-saw" like sound.

Jet (Exhaust) 5

The remaining hot air is fired out of the back of the engine at very high speeds, creating a strong, rushing noise. This jet noise is one of the loudest parts, especially during take-off.



Compressor 2

This section squeezes (compresses) the air to increase pressure before it enters the combustor. The blades inside spin at high speeds, generating a high-pitched whirring or whining sound.

Combustion Chamber 3

This is where fuel is mixed with the compressed air and burned. The combustion process causes rapid expansion of air and creates a roaring sound—this is where a lot of the engine's power and noise come from.

Turbine 4

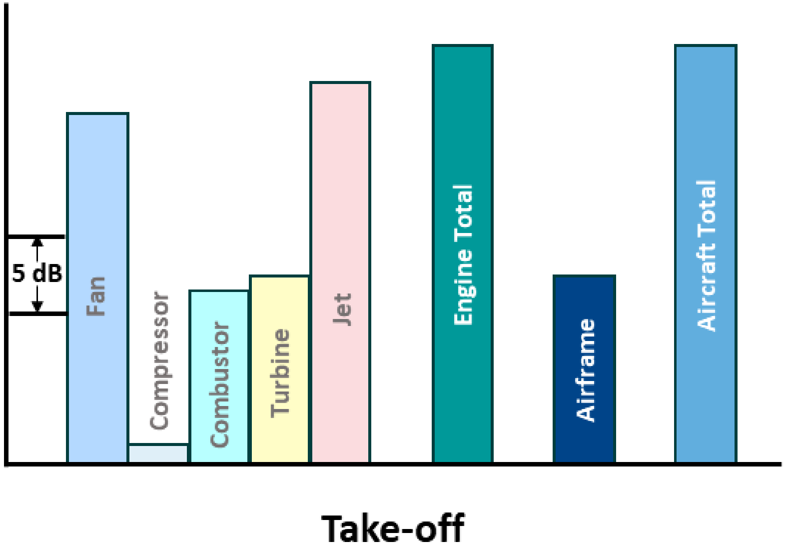
The turbine extracts energy from the hot gases produced by combustion to spin the fan and compressor. It makes noise as the high-speed gases rush past the blades, producing a deep whirring or humming sound.

Aircraft Noise at Source

Engine noise has the biggest impact on take-off, and an older jet engine may be as loud as 140dB*

Comparison of engine components and noise on take-off

Source: Airbus (2003) – Getting to grips with aircraft noise



Note: Values here do not 'add' to achieve the total value. A decibel (dB) is a ratio and adding two together is equivalent to multiplying the ratios represented by each. This explains why there is a small increase from the 'jet' noise, and the engine total.

Key Insights

Noise output
The level of noise created will depend on the aircraft size, type, weight, and engines used.

Certification flyover noise improvements
Since 2009, the average EPNdB of certified engines on different aircraft types has reduced by 6.0%.

Impact of altitude
Higher altitude significantly reduces engine noise because of the altitude and environmental effects.

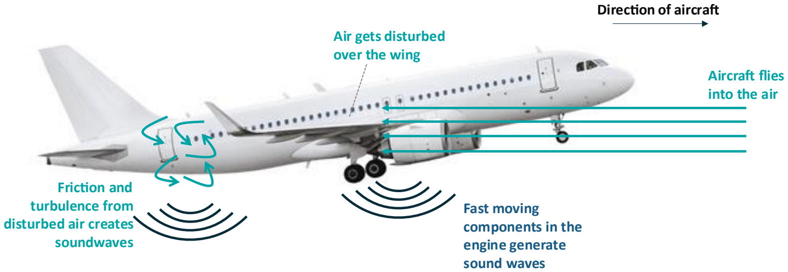
Estimated Environmental Noise	dBA
Jet engine at 100ft	140
City traffic	85
Aircraft at 4,000ft (departure)	70
Aircraft at 1,000ft (arrival)	68
Normal conversation	60–70
Aircraft in transit (approx. 36,000ft)	36

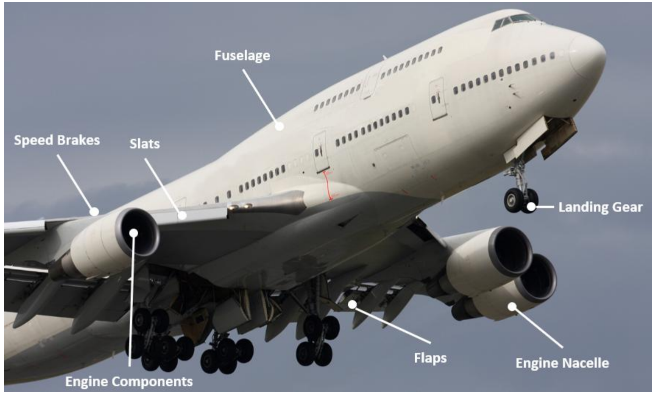
Source: Airbus, EASA, Yale, NATS
** Note: this sound is at the source*

Aerodynamic noise

Aircraft noise at source primarily comes from the engines and airframe of the aircraft.
Airflow around the aircraft's surfaces, especially at low speeds, generates **aerodynamic noise**.

Component	Use	Indicative Impact*
Flaps	Increasing lift to provide a lower approach speed to reduce the length of runway required to slow down after landing	Medium-High
Flight Control Surfaces	Moving the aircraft in flight	Low
Fuselage	The structure of the aircraft	Medium
Landing Gear	Used to affect the transition from flight to ground	High
Slats	Increasing lift and smooth the airflow at high angles of attack	Low-Medium
Speed brakes	Provides drag to assist the aircraft slowing down in flight and to dump lift during the landing roll	High
Wing	Generates lift to provide flight	Medium





Aerodynamic noise increases on decent as landing gear, flaps and speed brakes are deployed to help slow the aircraft down. These mechanisms increase the surface area of the aircraft, thus increasing drag and noise.

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*exact impacts will vary dependent on environmental and operational conditions.

Deploying flaps causes a stepped increase in noise

Flaps are used to help manage aircraft descent

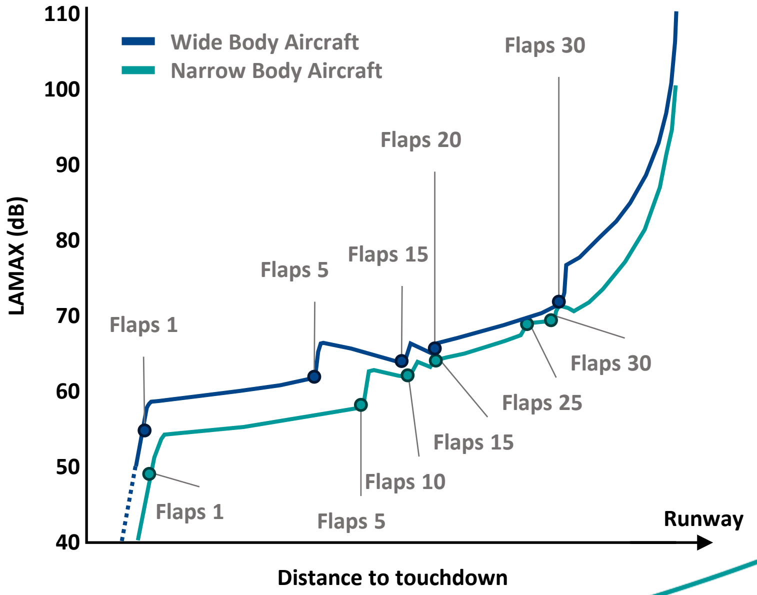
- Pilots are responsible for deploying flaps on an approach to help **manage the energy on descent**, by maintaining lift as the aircraft slows down.
- Pilots are guided by **Standard Operating Procedures** (SOPs).

The sound emission due to flap deployment is unclear

- Different stages of flaps have **different impacts on noise**. The sound emission of flaps is tied to how fast the aircraft is.
- The increase in noise is also due to the aircraft descending, meaning that less noise is dissipating before it reaches the ground.
- The CAA estimates that deploying flaps earlier than is optimal can carry a **noise increase of up to +1dB.**
- Using a lower flap setting during approach provides only a minor noise reduction, as it necessitates higher approach speeds, and may require the use of thrust.

Example noise levels under the flight track for different aircraft types

Source: Hansman and Thomas (2020) – Evaluation of the Impact of Transport Jet Aircraft Approach and Departure Speed on Community Noise

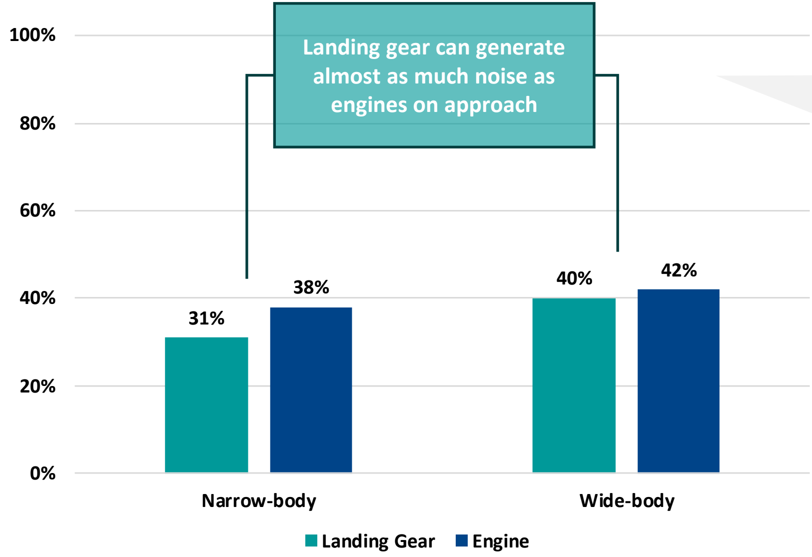


Landing gear size and shape impacts noise

Landing gears on larger aircraft types create more noise.

Indicative noise signature comparison of the landing gear and engines for narrow and wide-body aircraft

Source: Zhao et al (2020) – Noise reduction technologies for aircraft landing gear - A bibliographic review



For narrow body aircraft on arrival, **31% of the total noise** is generated by the landing gear. For wide bodies, **40% of the total noise** is generated by the gear.

For both aircraft types, the engines are the biggest noise source. For an A320, the noise from the landing gear is almost as loud as the total from all other sources on the aircraft (4dB difference) (Merino-Martinez et al., 2016)

The noise generated is hard to control as there are **strict limitations on the design** of landing gear.

Source: Airbus (2003) – Getting to grips with aircraft noise

Early landing gear deployment can lead to noise increases **up to 5dB**, according to the CAA. Deploying landing gear later in the descent reduces aircraft noise, but this **is not always operationally possible**. SOPs vary between different operators.

Source: UK CAA – CAP1165, Managing Aviation Noise

It is not always possible to delay landing gear deployment to the last moment due to external factors such as weather, both in terms of SOPs and the need to reduce aircraft speed.

Note: Decibels do not 'add up', and the rest of the aircraft noise sources each make up a component of the total noise.

Aircraft noise reduction can be driven by technological improvements

The **Boeing 787**, the world's first composite commercial aircraft is **significantly quieter than the 767** (which it aims to replace) and meeting strict night-time noise limits.

Source: UK CAA CAP1165

London Gatwick introduced charges to incentivise retrofitting Airbus A320s with a Fuel Over Pressure Protection (FOPP) system modification that removes a high-pitched approach tone and reduces noise; the fix became standard on all new A320s after 2014.

Source: UK CAA CAP1576

Newer versions of existing aircraft can deliver substantial noise reductions with lower cost and risk than entirely new types—for example, the **Boeing 747-8 Intercontinental offered a 30% noise improvement** over the 747-400.

Source: UK CAA CAP1165

The **Airbus A380** was designed with a strong focus on noise reduction, such as through its *low noise aero acoustic fan design*, making it one of the quietest wide-body aircraft in service and enabling it to meet ICAO Chapter 4 standards and **stricter night-time noise limits**, helping late-running departures to operate during the night quota period with **reduced noise impacts**.

Source: UK CAA CAP1165, Airbus

Introducing **new aircraft types is slow, costly, and resource-intensive**, with airlines typically following standard fleet replacement cycles despite noise reduction incentives, meaning **improvements to existing types remain important** for reducing noise in the near term.

Source: UK CAA CAP1165

The **Airbus A350 XWB**, a fuel-efficient composite wide-body aircraft carrying 250 – 350 passengers, was designed to deliver significantly improved **noise performance over older wide-body types**, though data was not yet available at its introduction.

Source: UK CAA CAP1165

The **Airbus A320 NEO** uses **quieter engines**, improved **wing design** (such as utilising sharklets for improved aerodynamic performance), and modifications to reduce specific approach noise.

Source: Airbus

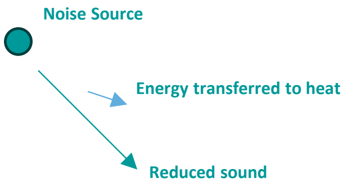
Impact of the Environment

1) Atmospheric absorption

What is atmospheric absorption?

As sound travels through the air, some energy of these travelling waves is absorbed into the air and converted into heat. This reduces the intensity of the sound further away from the source.

This phenomenon is known **as atmospheric absorption**.



The effects of atmospheric absorption are negligible over short distances and will have a greater impact the further the sound travels e.g. generally aircraft are quieter further from the ground as at a greater altitude sound must travel greater distances to reach the ground and become noise to those who do not favour it.

There are four main factors affecting atmospheric absorption

- **Frequency**
- **Wind**
- **Temperature**
- **Humidity**

The following pages provide more detail on each

Noise frequency

Definitions

Intensity is the amount of acoustic energy carried by sound vibrations and is expressed as sound pressure.

A greater sound pressure means the sound carries more energy, meaning it will be perceived as louder by the ear.

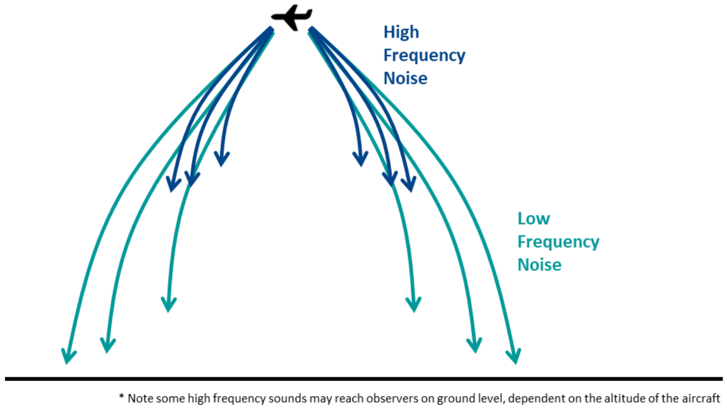
Frequency describes how many times per second the air vibrates or oscillates due to sound waves and is measured in Hertz (Hz).

How does frequency change the way the sound is perceived by the human ear?

- **Low-frequency** sounds are often heard as rumbles or roars.
- **High-frequency** sounds are commonly perceived as sirens or screeches.

How are these frequencies absorbed?

- **Low-frequency** sound travels further as the sound waves are less readily absorbed.
- **High-frequency** sound travels over shorter distance as the sound waves are more readily absorbed.



As a result, over long distances, the lower frequencies tend to dominate the sound environment.

This is because the higher frequencies diminish more rapidly through atmospheric absorption, leaving the lower-frequency to reach the ground.

Wind direction

How wind changes noise

Wind can significantly alter the way sound travels through the atmosphere, and variations in the speed and direction will change the nature of the noise heard.

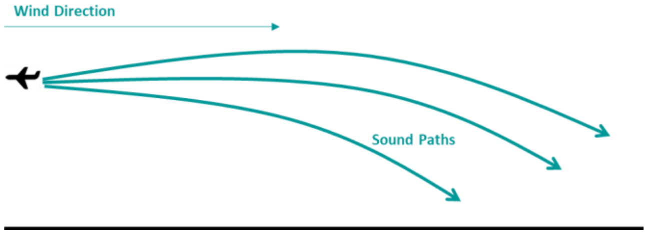
Wind will **amplify the noise** heard when it blows the noise source towards the receiver – a **downwind**.

An **upwind** may **reduce noise levels** as it carries sound away and bends sound waves upwards, limiting how much reaches the ground.

On a very windy day, the wind can **mask** aircraft noise and become the dominant noise source.

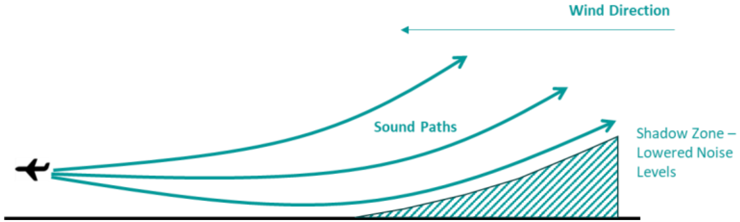
Downwinds

- Downwind occurs when the wind blows away from the noise source.
- This causes sound waves to speed up and can cause them to bend towards the ground.
- This can both amplify the intensity of the noise and the distance in which the sound is heard from.
- Noise may increase by a few decibels, but the effect is less pronounced than with upwind.



Upwinds

- Upwind occurs when the wind blows towards the noise source.
- This hinders the amount sound waves can travel and can cause sound waves to bend upwards.
- This can reduce the noise heard on the ground by as much as 20dB*
- In strong winds, a shadow zone can be created, where noise levels are reduced.



* Institute of Acoustics, 2015

Temperature

How temperature changes noise

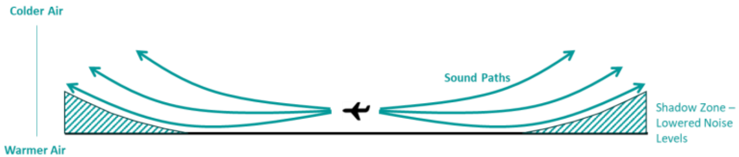
Changes in temperature with altitude can cause changes to the direction that sound waves travel.

The atmosphere cools as altitude increases; at typical aircraft cruising altitudes, temperatures can fall as low as -60°C.

This causes sound waves to bend upwards, **making noise less noticeable at ground level**. This is particularly common **on sunny, calm days** when the ground heats up, but the air above remains cooler.

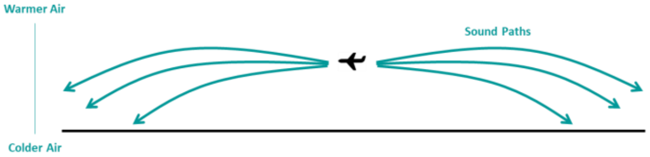
Normal conditions

- Sound travels differently depending on how temperature changes with altitude.
- If the **temperature is constant with height**, there is no **significant bending of sound waves**.
- However, when temperature gradients (changes in temperature with altitude) exist, they can refract sound in much the same way that wind gradients do.



Inversions

- A temperature inversion is when the air temperature increases with altitude.
- This causes sound waves to **bend downward** toward the ground.
- This can lead to **increased noise on the ground** at greater distance from the source.
- Inversions are most **common at night or early morning**, particularly under clear skies when the ground cools rapidly.



More humid environments will make aircraft seem quieter

Definitions

Humidity is the amount of water vapour in the air. It is normally expressed as **relative humidity**, which is the percentage of water vapour in the air compared to the maximum amount the air could hold at that temperature.

What will influence humidity?

- **Precipitation** (rainfall/snowfall) will change the amount of water vapour in the air.
- **Temperature** will alter the relative humidity.

How does humidity change the noise heard?

- **Lower relative humidities** will reduce the amount of absorption, meaning sound is perceived as louder.
- **Higher relative humidities** will increase the amount of absorption, meaning sound is perceived as quieter.
- Compared to temperature, **humidity has significantly less effect on noise**.

How does Precipitation change the noise heard?

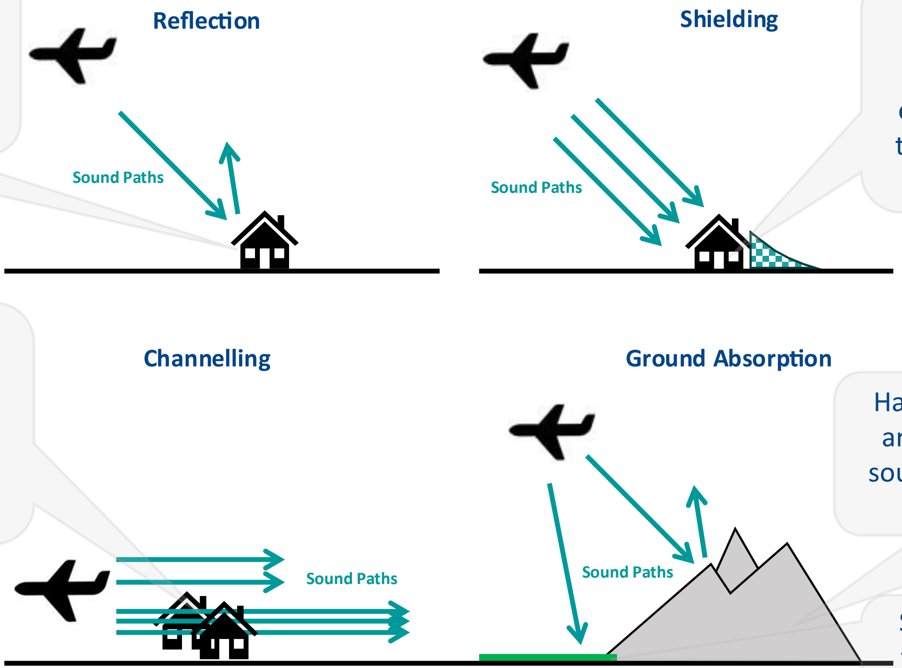
Precipitation will increase the humidity, and will change the ground surface, changing the way sound waves behave.

- **Snow significantly dampens sound**. The structure of snow, with its dense composition of tiny air pockets between ice crystals, strongly absorbs sound waves.
    - Environments covered with snow are quieter because there is minimal reflection of sound from the ground.
- The action of the rain hitting the ground will mask part of the aircraft noise.
    - Wet surfaces can reflect more sound compared to dry surfaces, making the perception of noise **louder under rainy conditions**.

2) The natural and built environment

Natural and built features can reflect sound waves, amplifying the noise in locations. In areas with steep terrain (such as hills), this can cause echoing.

Valleys, river corridors, and narrow gaps between buildings, can channel sound waves, allowing noise to travel further This can lead to higher noise levels at considerable distances from the source.



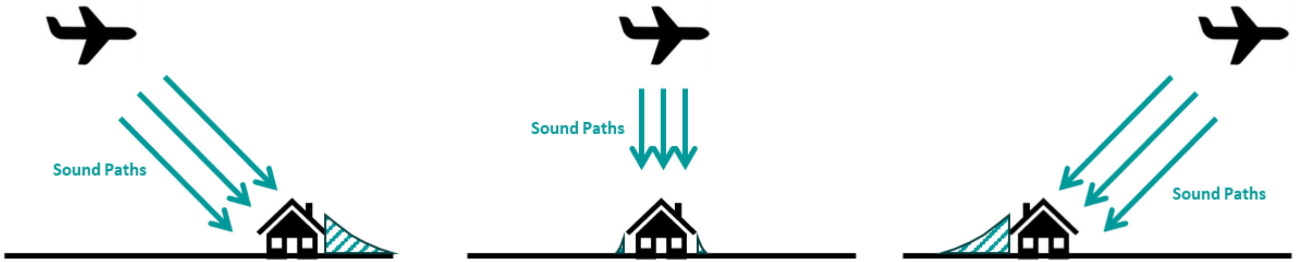
Hills, ridges, and dense forests can act as natural barriers, either blocking or absorbing sound energy. In some local areas, where there are a lot of buildings, this can create localised quieter areas.

Hard surfaces (rock, concrete, paved areas) reflect sound, and can cause sound levels to appear louder around these areas.

Soft surfaces (grassland, forests, farmland) absorb sound energy, helping to reduce noise levels at ground level.

The natural and built environment

While each of these effects happen, their impact depends on where the aircraft is. For example, shadow zones may form when an aircraft is overhead or to the side of an object on the ground, but these zones change and reduce as the aircraft moves. This is shown below.



For communities, this means that aircraft noise may sometimes seem louder or quieter depending on where you are. A “shadow zone” can make one area hear less noise while a nearby area hears more, and as the aircraft moves, these zones shift so the experience of noise on the ground can change quickly.

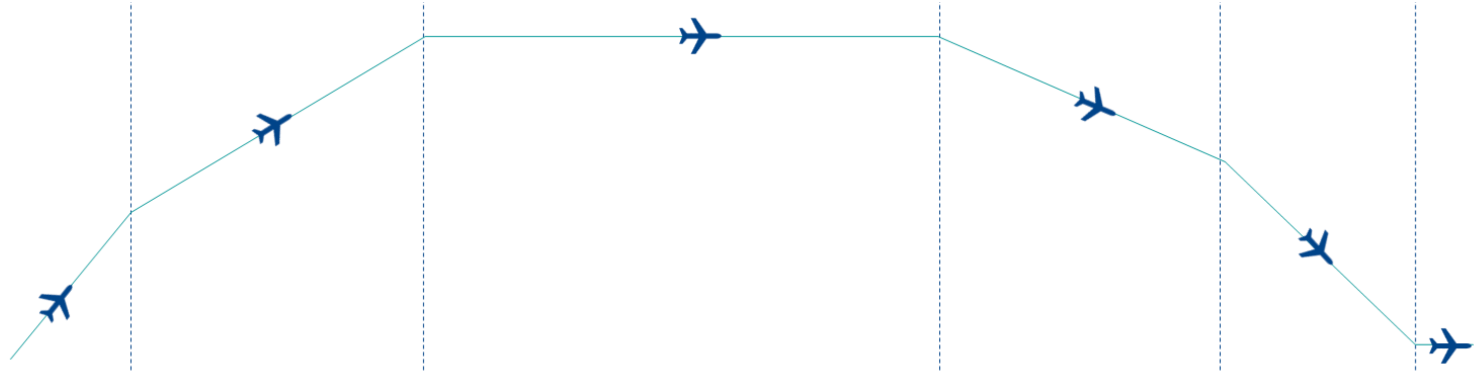
3) Combined atmospheric absorption and built environment effects

- Combined effects of atmospheric absorption and the built environment may amplify or reduce the perceived noise on the ground. The perceived noise is further impacted by aircraft configuration at different stages of flight.
- These effects can result **in varying noise experiences**, making it challenging to predict noise exposure accurately.
- In some cases, the combination of reflection, channelling, shielding, and atmospheric effects can create **complex patterns of noise hotspots** and quiet zones, **even within a single community**.

Operational Impacts

Operational Impacts

Aircraft phases of flight



Stage of flight	Initial Climb	Ascent	Transit	Descent	Approach	Ground
Main Noise Impactor(s)	Engines (highest power)	Engines (reduced power)	Engines (highly reduced noise on ground)	Flaps Airframe	Flaps and slats Speed brake Landing gear	Engines (reverse thrust)

What are the different noise impactors doing through the phases of flight?

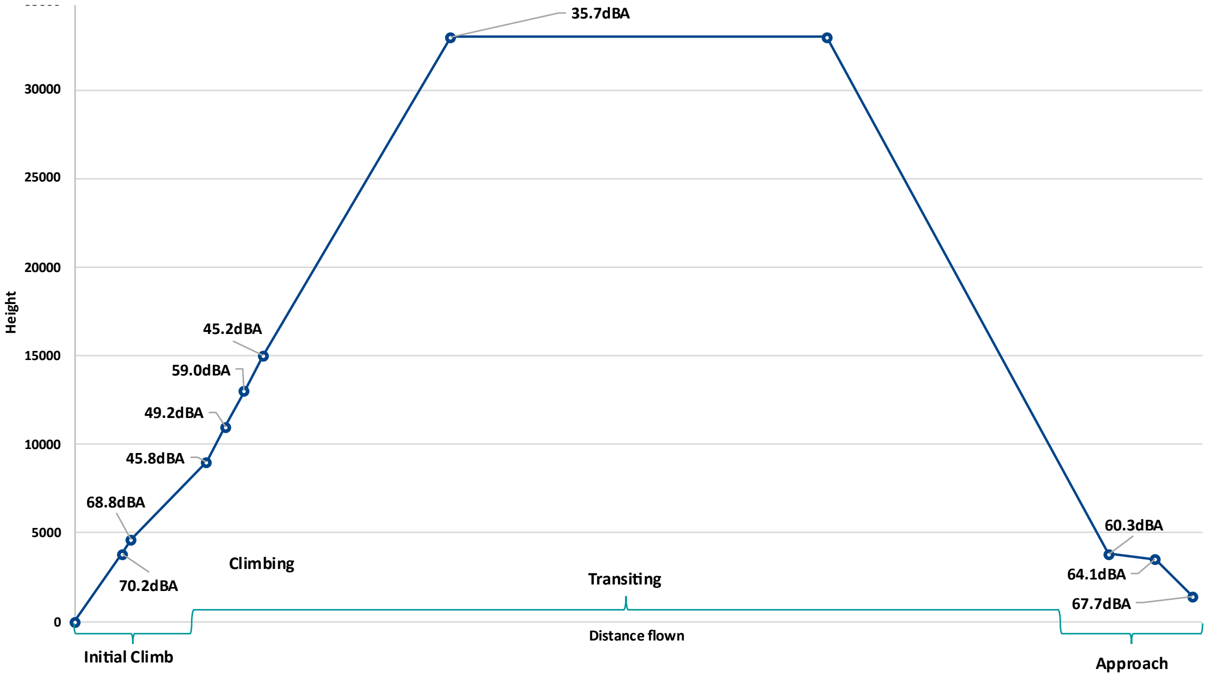
Engines	Max Thrust	Climb (reduced thrust)	Cruise thrust (optimum for fuel burn and speed)	Optimally Idle	Thrust as required to achieve approach speed	Reverse thrust
Flaps	Minimal after take-off	-	-	Minor use at lower stages and lower speeds	Increasing use (angle)	-
Landing Gear	Up quickly after take-off	-	-	Lower as required to achieve stable approach	Down near airport	Down
Speed brake	-	-	-	Used as required to slow the aircraft down	Used as required to slow the aircraft down	Max to slow aircraft down

Operational Impacts

Departure vs arrival noise

Noise experienced on the ground from various aircraft overflights

Source: NATS overflight recording and measurements



Source: NATS (See their website for illustrative videos: Measuring noise - NATS)

Key Insights

On average, aircraft are louder as they take-off and climb and are slightly quieter on descent. Noise on the ground is lowest during transit.

Mechanical noise
On departure, mechanical noise is most dominant (as thrust is highest).

Aerodynamic noise
On arrival, aerodynamic sources dominate as the aircraft slows down in preparation for landing.

Variation in noise heard
Flights in cruise (transit) are quieter as they are at higher altitude, where atmospheric absorption effects have a greater impact in reducing the strength of the sound waves.

Impact of operational and environmental factors on aircraft configuration and noise

Operational scenario	Impact on configuration	Impact on noise
Aircraft descends early in approach	Early deployment of flaps and gear May require additional thrust to maintain profile	Increased airframe noise from flaps/gear Engine noise from higher thrust
High-energy approach (high or fast)	May require a steep descent May use speed brake May deploy flaps and landing gear	Increased airframe noise (speed brake, flaps and landing gear)
Aircraft put into a hold (circling)	Flaps are retracted in a hold Thrust varies to maintain altitude	Fluctuating engine noise
Early deployment of landing gear	Landing gear extended Increased deceleration	Significant increase in airframe noise
Go-around / missed approach	Flaps and gear retracted High thrust	Loud engine noise surge Transitional airframe noise during reconfiguration
Heavy, hot ambient temperatures aircraft take-off	Maximum take-off thrust Slower acceleration Flaps used at higher settings for lift	High engine noise Moderate airframe noise from large flap settings
Tailwind approach or landing	Results in higher ground speed Will require an earlier configuration for landing	Higher risk of go-around due to unstable approach
Speed restrictions on an approach	Need to hold low speeds may require earlier flaps Sometimes thrust is added to maintain speed at the configuration	Combined engine and airframe noise

Next steps for the NMB

The work behind FAAN will help guide current and future NMB initiatives

Project Outcomes

- Collective understanding of aircraft noise sources through a pool of information.
- The report has highlighted how:
  - Environmental conditions can alter the noise heard on the ground.
  - Operational influences can have noise impacts, but safety must always be the focus for the industry.
  - Noise reduction is progressing with technological advances.
- This research is a foundation for the NMB to work off for future projects.

Key Next Steps

- Develop and publish **Noise Impact Table** on London Gatwick website.
- Establish a **review cycle** for the Noise Impact Table.

Future NMB and FAAN

How could the FAAN project be used?

- Supporting NMB onboarding for new members.
- Explaining what measures already exist to reduce noise.
- Foundation for further NMB projects to be scoped on.
- The Impact Table can be used as an evaluation tool to identify where the NMB is making positive impacts against these sources.
- Future NMB projects, such as the *Community Noise Simulator,* could make use of the findings.
- Distributed to relevant London Gatwick teams identified by the NMB.
- Supporting in noise enquiry and complaints process.

What could follow FAAN?

- Weather related noise impact mitigation – developing a system to inform of potential changes to the noise environment (i.e. a noise forecast).
  - This might be integrated into existing tools (e.g. WebTrak).
- Investigate arrival and departure concepts that result in later flap and landing gear deployment, bringing noise benefits.
  - FASI-S, UK-ADS and other contexts need to be investigated.

Annex

Annex

A.1 Reference Bank

Industry Publications (UK)

CAP 1165 | Managing Aviation Noise

CAP1576 | Environmental charging - review of impact of noise and NOx landing charges: update 2017

London Luton Airport, 2017 | Delayed Landing Gear Deployment Trial Report

NATS - Measuring Noise

Industry Publications (Europe)

Airbus, 2003 | Getting to grips with aircraft noise

Airbus, 2015 | Design to lower noise

EASA, 2025 | EASA Certification Noise Levels – Jet aeroplanes noise database (Issue 49 of 14 March 2025)

Industry Publications (Global)

Federal Aviation Authority (USA)

Yale Environmental Health and Safety | Decibel Level Comparison Chart

Academic References

Antione and Kroo, 2002 | Optimizing Aircraft and Operations for Minimum Noise

Bennet et al, 2018 | Noise Characterization of a Full-Scale Nose Landing Gear

Bertsch et al, 2015 | Aircraft Noise : The major sources, modelling capabilities and reduction possibilities

Boorsma et al, 2008 | Perforated Fairings for Landing Gear Noise Control

Dobrzynski et al, 2001 | Model and full scale high-lift wing wind tunnel experiments dedicated to airframe noise reduction

Hansman and Thomas, 2020 | Aircraft Speed Impacts on Community Noise Report

Institute of Acoustics, 2015 | Mitigating the effect of weather on environmental noise measurements

Liptai et al, 2015 | Influence of Atmospheric Conditions on Sound Propagation - Mathematical Modelling

Merino-Martinez et al, 2016 | Analysis of landing gear during approach

Merino-Martinez et al, 2021| Experimental study of realistic low–noise technologies applied to a full–scale nose landing gear

Pauly et al, 2022 | Improved energy management during arrival for lower noise emissions

Zhang et al, 2024 | Slat noise in high-lift systems

Zhoa et al, 2020 | Noise reduction technologies for aircraft landing gear-A bibliographic review

A.2 Summary of Numerical Noise Impacts

Engines

Summary	Value	Source
Reduction of engine certification EPNdB (from 2019)	-6.0%	EASA, 2025
Estimated engine noise reduction from high bypass ratio engines (since 1960)	20dB	Antione and Kroo, 2002
Jet engine at 100’	140	Yale

Flaps and Slats

Summary	Value	Source
Flaps 1 to Flaps 5	+3dB $L_{A,max}$	Hansman and Thomas, 2020
Full Flaps	+10dB $L_{A,max}$	Dobrzynski et al, 2001
Impact of incorrect flap settings	1dB	CAP1165

Landing Gear

Summary	Value	Source
Proportion of Landing Gear Noise	30-40%	Bennet et al, 2018
A320 nose landing gear noise level	125dB (OASPL)	Merino-Martinez et al, 2016
Impact of early deployment	3-5dB	CAP1165
Reduction from later landing gear deployment	-2.7dB at 6nm -3.4dB at 7nm	London Luton Airport, 2017

Noise Management Board | Factors Affecting Aircraft Noise

Noise Management Board

Dr Rebecca Mian | Programme Steering Group Lead
Rachel Thomas | Expert Advisor
Charlotte Smerdon | Project Manager
Joseph Branagan | Programme Steering Group

For NMB enquiries, please email the Secretariat at *GatwickNMB.UK@egis-group.com*

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