

10. Annex B Airport review – operations – metrics and tools

10.1. Annex B.1 Stakeholders & Collaborative Environmental Management (CEM)

Stakeholders

In aircraft operations near airports one might observe that different stakeholders weigh operational and environmental aspects differently:

- For communities around airports limiting or decreasing the impact of both noise and exhaust emissions related to air quality (NO_x and PM) is important.
- For airlines operational costs/revenues and sustainability goals are both on the agenda. Less fuel burn means economic savings and less CO₂ emissions.
- For authorities/regulators it is important that airport and airline operations are safe, that impact on health and the environment is within the imposed limit values and that the airport contributes to the national, regional or local economy.
- For ANSP's a safe, efficient air operation is leading.
- The airport wishes to have a balanced operation in accommodating the airlines (air transport (growth)) and the needs of the community around the airports, working together with regulators and ANSP's, and - last but not least - serving their own interests in being a viable, responsible and responsive 'entity'.

Collaborative Environmental Management (CEM)

To find common solutions to the environmental challenges related to operations at and around airports, Eurocontrol⁸⁹ has developed the Collaborative Environmental Management (CEM) concept.

CEM promotes a collaborative approach between all the actors at an airport, so that they can find collective 'environment' solutions that take account of all the interdependencies between them and so that they can realise the maximum potential for the sustainable growth of the airport. CEM also helps the airport to have a robust and transparent dialogue with external stakeholders.⁹⁰

The noise and emissions trade-offs topic is a good example to test the viability of this concept.

⁸⁹ CEM- Collaborative Environmental Management: <https://www.eurocontrol.int/collaborative-environmental-management-cem>

⁹⁰ <https://www.eurocontrol.int/news/collaborative-approach-environmental-management>

10.2. Annex B.2 Operations

Aircraft operations associated with trade-offs or interdependencies are well documented in industry and academic literature. As example Sustainable Aviation⁹¹ provides a detailed overview of the Operational Inter-Dependencies regarding the noise, CO₂ and NO_x (LAQ) impact in Departure, Arrival and Ground phase of flights (see tables B.1, B.2 and B.3).

Technique	Noise Impact	CO ₂ Impact	NO _x Impact (LAQ)	Comments
Increasing take-off power	Reduces under flight-path, but footprint area can be increased	Slightly altered Note 1	NO _x increases with power	Note 2. Adverse impact on engine maintenance costs
Reducing take-off flap setting	Reduces noise if lift-to-drag ratio improved - dependent on aircraft & runway characteristics	May be slightly reduced	Slightly changed, dependant on aircraft & runway characteristics	Note 2. Possible implications for tail strike under certain conditions
Reduce acceleration altitude	Noise increased close to airport, reduced further out	Reduced	Note 3	Note 4. Actual differences depend upon the difference in selected acceleration altitude versus standard airline practice.
Delayed flap retraction in the climb	Noise reduced close to airport, slight increase further out	Increased	Note 3	Note 4.
Increased cut-back altitude	Noise increased at some parts close to airport, reduced further out	Slightly reduced or increased, depending on flap retraction schedule.	Note 3	Note 4.
Reduce power, retract flaps, then accelerate	Reduced noise under flight-path, after normal acceleration point.	Increased	Note 3	Note 4. Aircraft in high-drag configuration with low power set may concern regulators.
Increase VR, V2 and climb speeds	Noise slightly increased close to airport, reduced further out	Minimal change	May increase or decrease depending on take-off thrust setting method	Not applicable to some aircraft types and some operators. Depends upon take-off performance limitations
Increasing climb power settings	Noise increases after cutback closer to the airport, reduces further out	Slightly reduced	Note 3	Note 4. Adverse impact on engine maintenance costs
Novel Power Management (Managed Noise)	Reduced at specific points identified as sensitive for noise.	Dependant on procedure, aircraft and airport requirements.	Note 3	Note 4. Currently only feasible with latest aircraft such as A380, A350, B787

Table B.1 Departure (Sustainable Aviation 2017 Update, Appendix B)

⁹¹ https://www.sustainableaviation.co.uk/wp-content/uploads/2018/06/FINAL_SA_InterDependencies_2017.pdf

Note 1: Although fuel flow is greater at the higher power setting, the time at that setting will be shorter, resulting in slight differences in overall fuel-burn that can be either positive or negative and will not be the same for all aircraft.

Note 2: Legal constraint: Noise Abatement Departure Procedures (*NADPs*) are not allowed below 800 ft (PANS-OPS/EU-OPS).

Note 3: Changes in NO_x emissions above 1000ft *aa* have negligible impact on local ground-level NO_x concentrations [ICAO, 2008].

Note 4: Will have an impact on flight path and speeds, so will need to keep ATC advised, and may affect adherence to Noise Preferential Routes with low level turns.

Generally speaking Table B.1 shows that for a number of Departure techniques noise level may decrease and emissions may increase and also that noise may both decrease and increase depending on the area considered near the airport.

Technique	Noise Impact	CO ₂ Impact	NO _x Impact (LAQ)	Comments
Continuous Descent Operations (CDO)	Reduced	Reduced	Little or no difference	Note 5, Note 6 Procedures need to be set up. Greatest benefit will occur when initiated at higher altitudes with more advanced navigation equipment, though might impact airspace capacity.
Low Power/Low Drag (LPLD)	Reduced closer to the runway threshold	Reduced.	Slight reduction	Note 6, Note 7, Note 8 ICAO-stabilised approach criteria may also act as a constraint.
Steep Approach	Reduced overall, though there may be some changes in the geographical distribution of noise, due to different flap and landing-gear extension points	Reduced.	Note 9.	Note 7, Note 8 Legal constraint: Steep approach cannot be implemented solely for noise abatement purposes. [ICAO]. LVP considerations may also limit application.
Curved Approach	Reduced, though dependant on the distribution of local populations	Dependent on difference in track miles.	No difference below 1,000 ft <i>aa</i>	Note 5, Note 7 Procedures need to be set up, and more advanced navigation equipment will be required.
Displaced or Inset Threshold (Note 10)	Note 9	No difference	Note 9.	Note 6, Note 8

Table B.2 Arrival (Sustainable Aviation 2017 Update, Appendix C)

Note 5: Reductions arising from these techniques are achievable above the ILS capture altitude. Below ILS capture, there is no noise or emissions benefit relative to standard approach.

Note 6: Safety considerations might preclude reductions in flap setting if runway is short or wet/contaminated.

Note 7: May require specialist aircraft and/or ground equipment to be installed, as well as additional training for aircrews

Note 8: May result in increased use of reverse thrust, potentially eroding some of the benefits of the technique.

Note 9: Slight reduction in area impact, since low-level noise/emissions take place closer to (or within) the airport boundary

Note 10: Moving the threshold along the runway so that it is further within the airport boundary

Technique	Noise Impact	CO2 Impact	NOX Impact (LAQ)	Comments
Taxi-Out with engine(s) not operating	Reduced, though may be masked by higher power from operating engine(s) Note 11	Reduced	Reduced	Safety issues may limit the extent of deployment – i.e. not suitable for all flights in all conditions. Operational requirements may mean that the APU has to be running which will reduce the benefits. Use may in some cases conflict with airport efficiency considerations.
Taxi-in with engine(s) shut down	Reduced, though may be masked by higher power from operating engine(s) Note 11	Reduced	Reduced	Safety issues may limit the extent of deployment – i.e. not suitable for all flights in all conditions. Operational requirements may mean that the APU has to be running which will reduce the benefits.
E-Taxiing	Reduced Note 11	Reduced	Reduced	Trade-off between on-ground fuel-burn saving and in-air fuel-burn penalty due to system weight – best suited to short-to-medium range flights.
Towed taxiing	Reduced Note 11	Reduced	Reduced, though the type and/or technology standard of the aircraft tug will determine the extent of the reduction	Nose wheel leg strength, and taxiway congestion may be an issue at some airports – some aircraft may need specialist tugs. Instances of <i>FOD</i> will be reduced.

Table B.3 On Ground (Sustainable Aviation 2017 Update, Appendix D)

Note 11: In most cases, changes in noise levels beyond airport boundary are expected to be minimal, being masked by higher noise levels from aircraft in flight (arriving/departing)

The presented Arrival and Ground techniques almost always lead to win-win situations for noise and emissions. For take-off there are significant trade-offs possible. For descent and approach, operational choices can result in environmental benefits without any trade-offs.

10.3. Annex B.3 Airport case studies with interdependencies and trade-offs

Description of the airport case studies tackling interdependencies/trade-offs

The information presented in this sub-chapter is extracted from D2.5, which summarises the work conducted in ST2.3.1 (Balanced Approach implementation), as required by the description of ST2.3.3 on interdependencies.

10.3.1. Annex B.3.1 Heathrow

In 2017 London Heathrow Airport (LHR) served just under 476,000 annual aircraft movements, carrying approximately 78m passengers. Located 21km west of central London, the airport employs over 76,000 people - half of whom live in the surrounding five London Boroughs. The airport is operated by Heathrow Airport Holdings Ltd (HAHL) a consortium comprising 7 organizations. In July 2015, the airport was recommended by the Airports Commission that the

airport be granted a third runway, so as to improve its operating capacity, and in June 2018 the UK cabinet signed off plans that had been approved by the Government's economic sub-committee. This highly contentious runway has the potential to add an additional 222,000 aircraft movements to the airport.

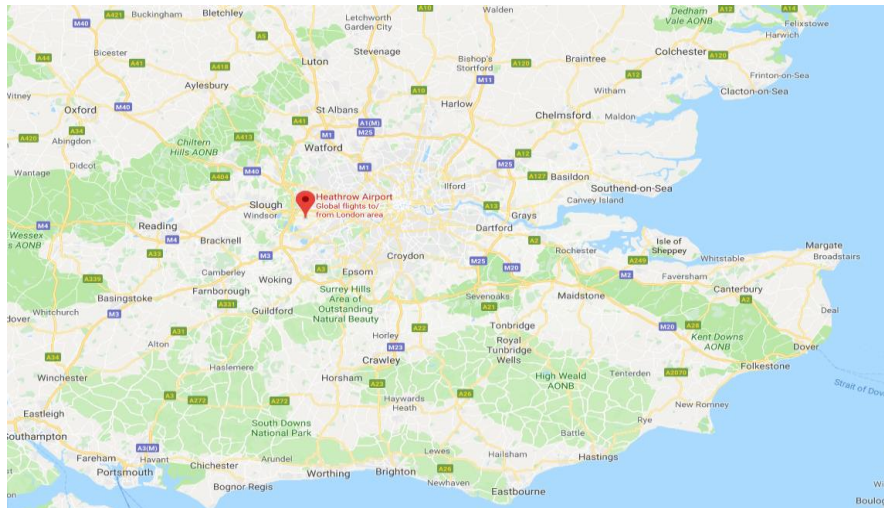


Figure B.1 Heathrow Airport geographical position

The continued development of Heathrow's approach to noise is visualized in figure B.2 below, taken from the airports 2018 document "Our Approach to Noise"⁹².

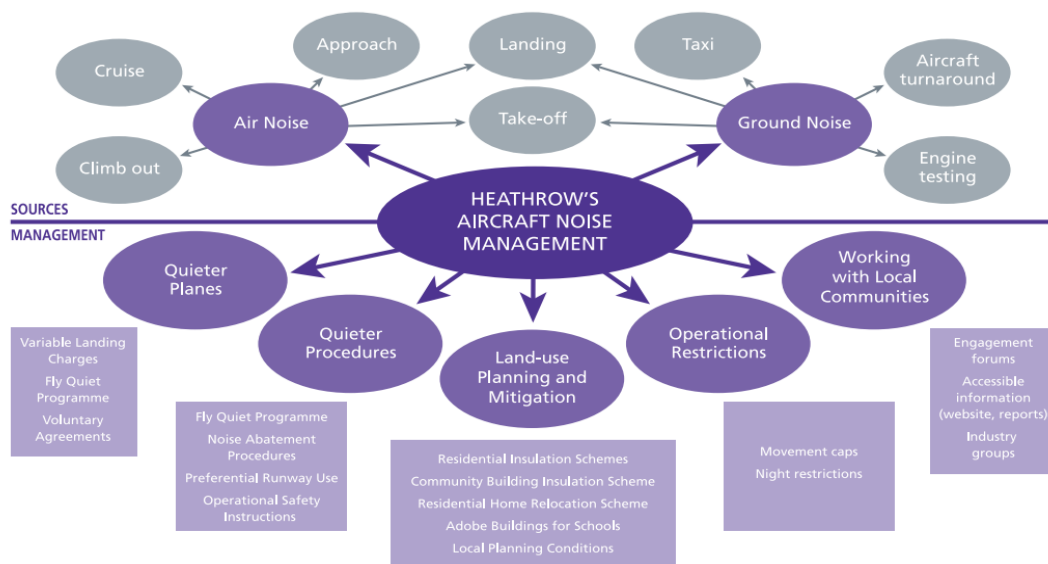


Figure B.2 Heathrow Airport's approach to noise management

⁹² <https://www.heathrowconsultation.com/wp-content/uploads/2018/01/6746-Expansion-Noise-v11-KL.pdf>

Heathrow airport has moved over time from noise monitoring to working to actively reduce noise impact, first through the implementation of noise related landing charges in the 1970s, but by the turn of the century including night flight restrictions, revised departure noise limits, voluntary daytime noise insulation schemes, flight track_improvements, and the 'pioneering' of the continuous descent approach.

Hence, the airport had been effectively engaging in the 4 Balanced Approach elements prior to its official implementation into EU legislation in 2002, as well as working closely with communities for many years. The airport Noise Action Plans also refer to ***the concept of interdependencies***, which refer to carbon emissions and air quality implications of the airport's operations. The reports state that operational controls need to be balanced. For example, they give the example of reducing thrust to lessen NOx emissions has the impact of increasing noise lightly for those under the same flightpath. *The airport has also been in a number of studies to help **investigate interdependencies in detail, and to quantify the most appropriate balance of these issues in specific situations.***

The airport also operates a '[Fly Quiet and Green Programme](#)' which benchmarks aircraft in terms of noisiness. Results are published quarterly in a league table that enables good performing airlines and those who have been improved to be identified. For noise, airlines are ranked against 'noise quota per seat', Chapter certification, early or late movements (between 23:30 and 04:30), continuous descent approach violations, and compliance of flying 'noise preferential routes'.

Operational Procedures

Heathrow airspace is managed with the aim of reducing noise impact (considering interdependencies such as safety, carbon emissions and air quality), doing so by working with local communities to identify potential changes and their impacts. This includes a focus on providing respite to communities from early morning arrivals and on some departure routes. Heathrow defines three broad categories that aim to make operations 'quieter':

- Making individual aircraft quieter (i.e. by changing thrust settings during take-off and approach).
- Making aircraft higher (i.e. when flying over communities).
- Managing aircraft routes differently (to avoid populated areas).

The airport works with the UK Civil Aviation Authority, NATS and airlines to explore and employ smarter operating procedures that fulfil these objectives, with measures reported by the airport including:

- Aircraft are required to be at a height of not less than 1000 ft aal (above aerodrome level) at 6.5 km from the start of roll, as measured along the departure track of that aircraft.
- There are noise limits applied at fixed noise monitors for departing aircraft and fines are enforced for breaches.



- Aircraft departing from Heathrow are required to follow specific paths called **noise preferential routes (NPRs)** up to an altitude of 4000 ft.
- **4% minimum climb gradient** between 1000 and 4000 ft.
- Westerly preference on departures to reduce the number of aircraft flying over London.
- **Continuous Descent Approaches to reduce noise emissions** for communities under arriving aircraft en-route to the final approach.
- Limiting use of reverse thrust at night by arrivals.
- Runway alternation/rotation: During westerly operations, wherever practicable the arrival runway is alternated according to a published schedule.
- Joining point rules: Between given times for aircraft approaching specific runways and using the Instrument Landing System (ILS) the aircraft shall not descend on the glide path below a given altitude before being established on the localizer, nor thereafter fly below the glide path.
- Slightly steeper approaches of 3.2 degrees compared to the standard 3 degrees.

Thus, the approach to operation at Heathrow airport gives several indications of tackling interdependencies. One such example is the Steeper departure Trial:

Case Study (Operational Procedures): Heathrow DET09 Steeper Departure Trial

The intention of introducing this case study is to investigate the processes that underpin best practice at London Heathrow. In so doing providing context surrounding the actions undertaken, and decisions made in reducing noise impact. To recap the process described in the methodology, this process takes the airport from an initial awareness of a noise problem or requirement for change, through to the design of interventions, the selection of an appropriate intervention option, and its subsequent implementation, and post-implementation evaluation.

Aircraft leaving Heathrow are required to be at an altitude of at least 1000ft, 6.5Km after the start of their take-off roll (UK AIP EGLL AD 2.21). From this point, they are required to maintain a gradient of at least 4% until reaching 4000ft AAL. This is not part of the standard Instrument Flight Procedure (IFD), rather it is something implemented by the airport for noise abatement purposes to ensure that noise is progressively reduced along the ground (see figure B.3).

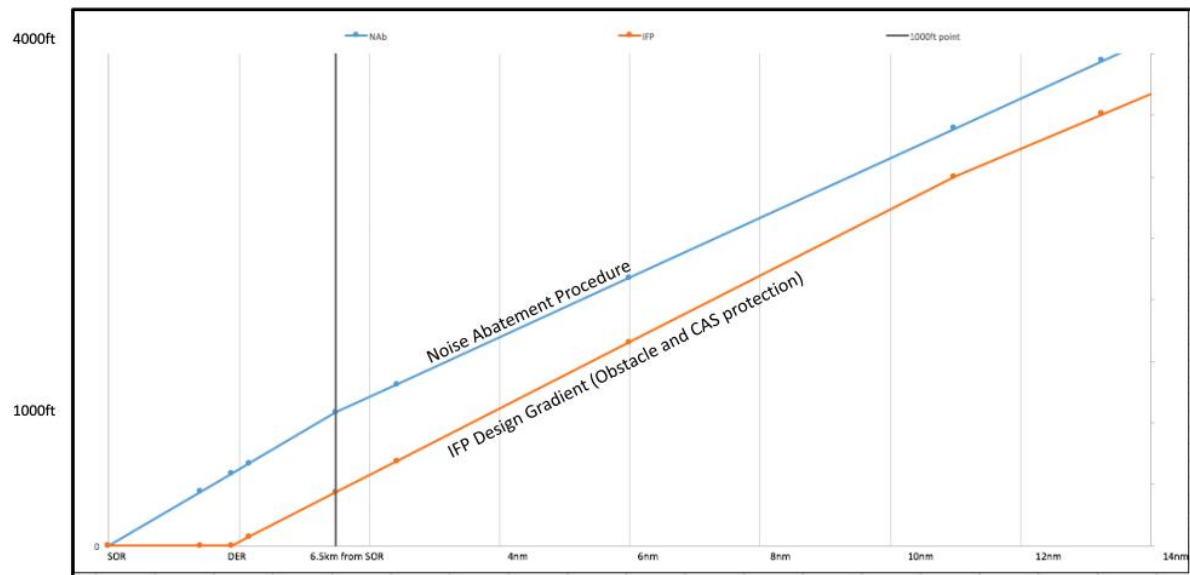


Figure B.3 Illustrating how the airport's noise abatement procedure results in aircraft being higher than they would be following the IFP design gradient

Although this gradient has existed for many decades, technology to monitor compliance has only recently existed, with Heathrow only collecting and reporting data since January 2017, as part of the airports regular flight performance reporting. The overall compliance rate in 2017 was 99.8%, with the majority of compliance failures being due to A380 operations.

4% NAB v IFP v Actual v Proposed 5% NAB

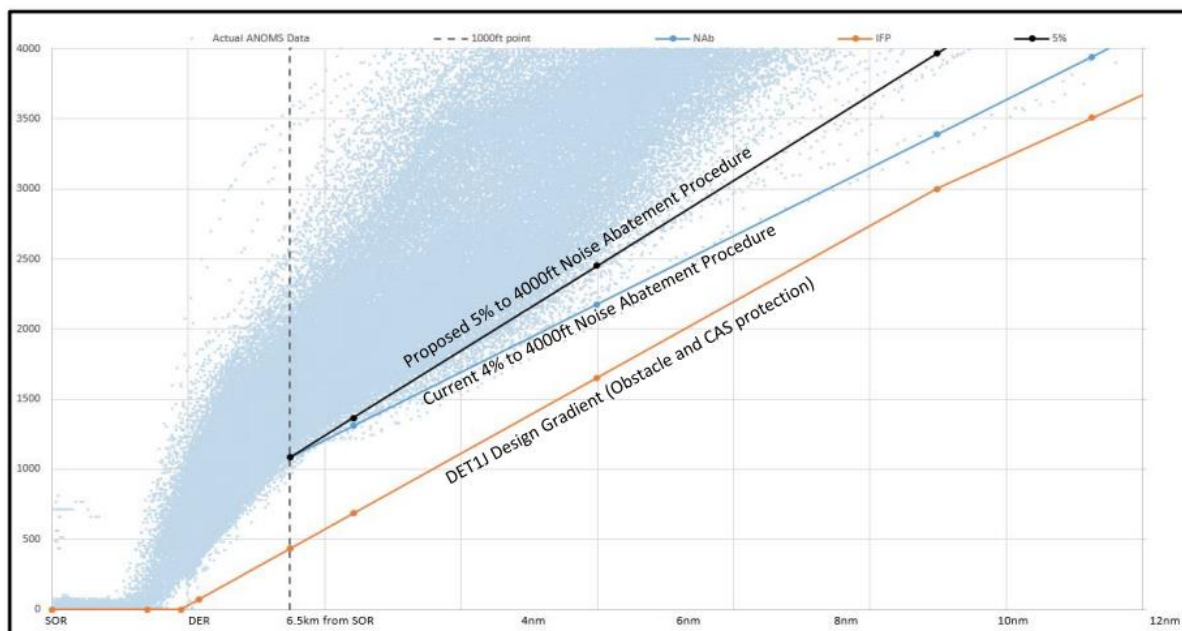


Figure B.4 Illustrating the results of the analysis, showing how the vast majority of flights were well in exceedance of the 4% and 5% departure gradients.



The report was based data collected from noise monitoring terminals in the area, and for the wider geographical area, on the Heathrow INM model. The airport uses the INM model as its primary tool for noise modelling, however, they acknowledged that modelling is complementary to monitoring and should not be used exclusively. For this reason, data was also assessed from the airports existing noise monitors in the area.

In terms of **interdependencies**, the CAA made it clear that any changes made to the departure profile would not be allowed to result in an increase in emissions below 1000ft (hence another reason why the 5% departure profile was selected – steeper profiles would not have been in compliance with this). Safety was also a concern as it is the main priority underpinning all operations at Heathrow. A joint risk assessment was held with airlines and NATS to determine any other operational impacts. This determined that a steeper departure would have affected the flow of aircraft leaving the airport as steeper climbing results in slower speeds. Moreover, aircraft that would not be able to meet steeper profiles would need accounting for and would also cause significant logistical issues. Steeper climbs also meant that aircraft would reach 600ft more quickly (the restriction altitude for Heathrow SIDs). The airport had to consider how this would interact with other airports' routes and how that is affecting continuous climb operations.

Rather than go immediately ahead with implementing the new departure gradient as part of their SID, Heathrow decided to first trial the new procedure. This decision was made based on an **awareness that changes to a flight path would have implications in terms of interdependencies** – namely, fuel burn, emissions, safety, and changes to the distribution of noise along the ground based on the fact that changes to operational procedures do not reduce noise, but rather move it into different places. The suspicion here would be that whilst a steeper departure profile would reduce noise exposure in the Teddington community, it would increase noise closer to the runway, and along the side lines of the flight path. This is clear evidence of a high-level of knowledge about noise distribution and the consideration of interdependencies in the noise management process.

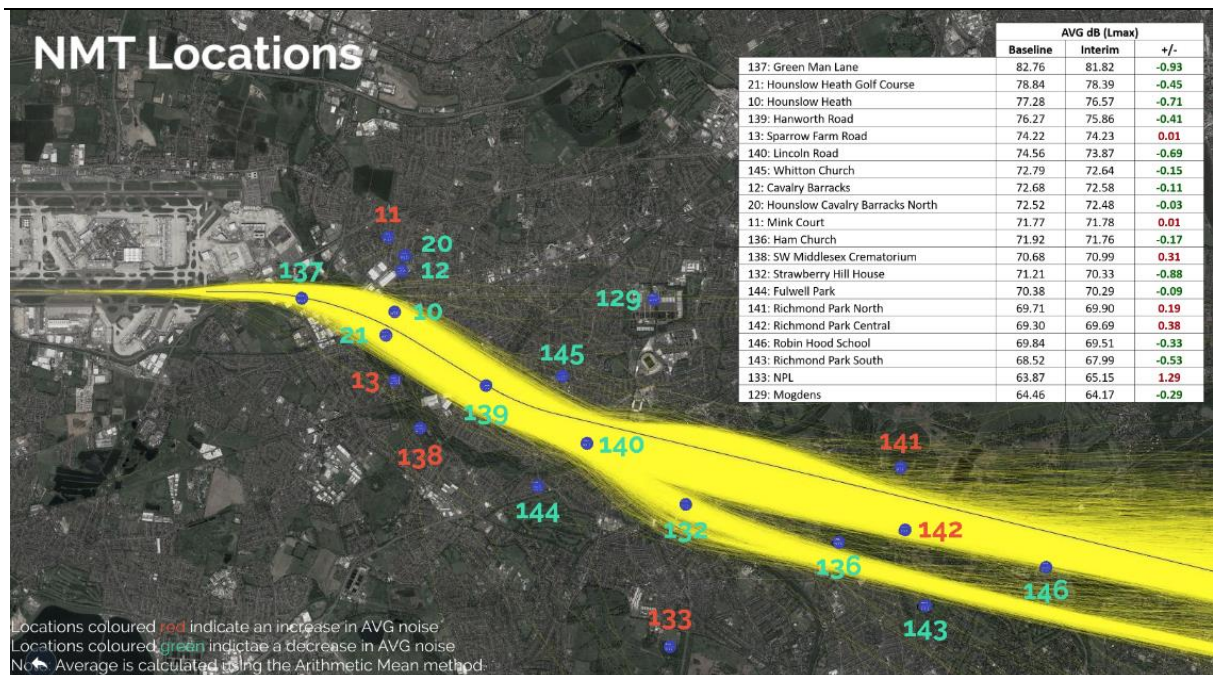


Figure B.5 Location of Noise Monitoring Terminals and differences in AVG dB (max) between the baseline period and interim trial results

Following the above described processes, modelling and regulatory procedures have ensured a safe and successful trial. Success was determined through the array of class-one microphones and monitoring stations deployed around the airport and the subsequent analysis of collected data.

In conclusion, being the first such study of its kind in the world, the Detling Steeper Departure Trails can be seen as a leading example of an operational procedure intervention, a good example to assess interdependencies between noise and (carbon) emissions.

10.3.2. Annex B.3.2 Barcelona

In 2018 Barcelona airport saw the record figure of 50,172,457 passengers, 6.1% more than the previous year, as well as 335,651 operations and 172,940 tonnes of cargo. The airport is open 24 hours a day and can handle 90 operations/hour (78 slots/hour currently). The airport can process 55 million passengers/year (Terminal T1: 33 million pax + Terminal T2: 22 million pax). A new Masterplan is needed for this airport in these moments, new challenges for all stakeholders.



It is the 7th busiest airport in Europe and 17th in the world. Located in “El Prat de Llobregat”, 15 km southwest of central Barcelona, the airport is the main driver of the Catalanian economy.

The airport is operated by AENA, the world's leading airport operator by number of passengers. AENA is a state-owned company that manages general interest airports (46) and two heliports in Spain. Through its subsidiary company Aena Internacional it also participates in the management of 17 airports abroad.

The airport implemented a basic operations configuration based on landings on runway 25 and take-offs on runway 20, which made it possible to increase the capacity of the airfield progressively from 38 operations per hour to 50.



From 1995, Barcelona-El Prat Airport was consolidated as one of the top 15 airports in Europe and one of the top 50 in the world.

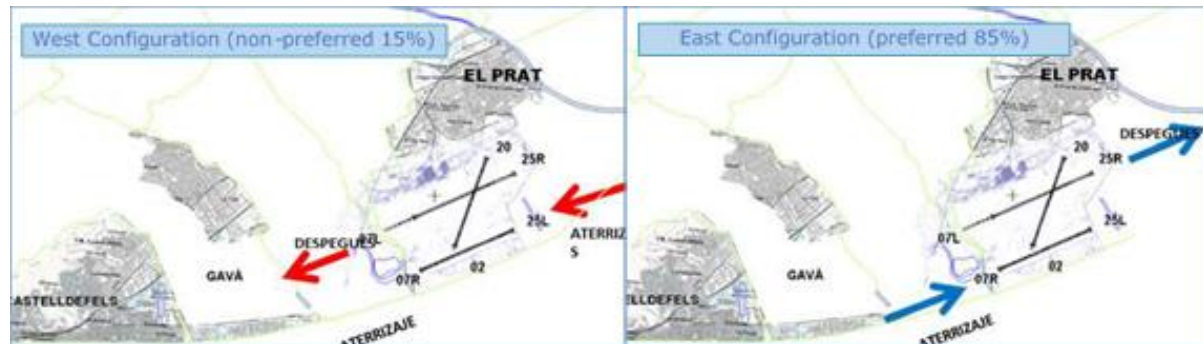
In 1999, the Ministry of Public Works approved the Master Plan for Barcelona-El Prat Airport, formally implementing the Barcelona Plan, the third great transformation operation of the airfield was inaugurated in September 2004 and brought the third runway, parallel to the main runway, into service.



This new infrastructure is equipped with the maximum category runway lighting facilities (ILS Category II/III systems in each departure point). This enables its

use in both directions and in foggy conditions. Runway 07L-25R has also been lengthened to 3,743 meters and widened to 60 meters.

The construction and introduction of the third runway in September 2004 and the extension to the primary runway were decisive steps to increase the airport's capacity to reach 90 operations per hour.



The whole project of the new Master Plan was approved, and got an **Environmental Impact Statement** as the result of a complex and participatory process in 2002 (lengthy discussions with the territory to preserve certain sites of Community Importance).

Barcelona Operational Procedure Case: Switching the role of each runway during the day (the ones that would be used for take offs, should be used for landings and vice versa), and new flight configuration during the night.

Barcelona airport was an infrastructure close to the sea and therefore didn't use to have significant noise problems. The planes could take off or land using tracks over the sea or over the industrial area of Barcelona to the East. Only Western areas like Castelldefels that had experience with airport noise were used to and were aware of the problem.

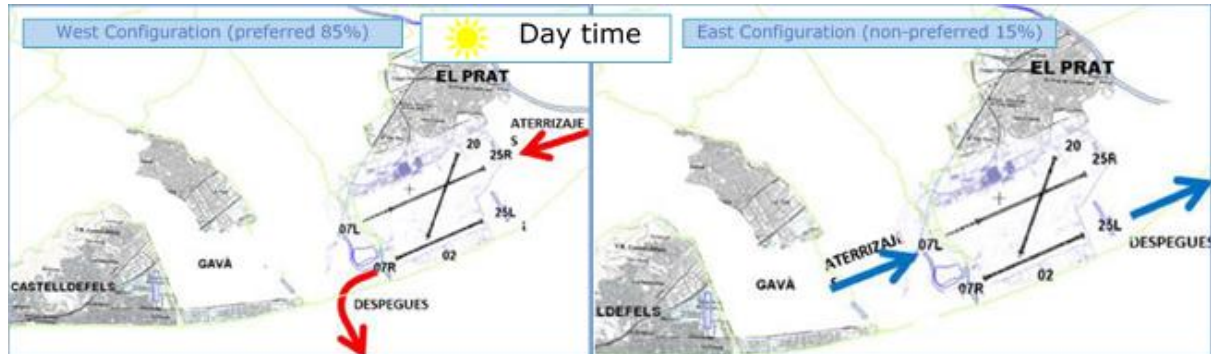
The main problem was the noise impact due to a non-preferred operation configuration. There were people really affected by "normal" airport noise in less frequent flight paths (non-preferred configurations). There are non-preferred tracks of use of each airport but still within "normal" operation. Most airports operate with a preferred configuration for take offs and landings (usual tracks and runway ends for departures and landings most of the time throughout a year). Depending on the orientation and intensity of the wind, it is sometimes necessary to change to an alternative configuration (normally this alternative configuration involves switching the roles of the runways, in other words the ones used for take offs are used for landings and vice versa) in which aircrafts use tracks that are not as common but perfectly well-known and "normal".

The Solution

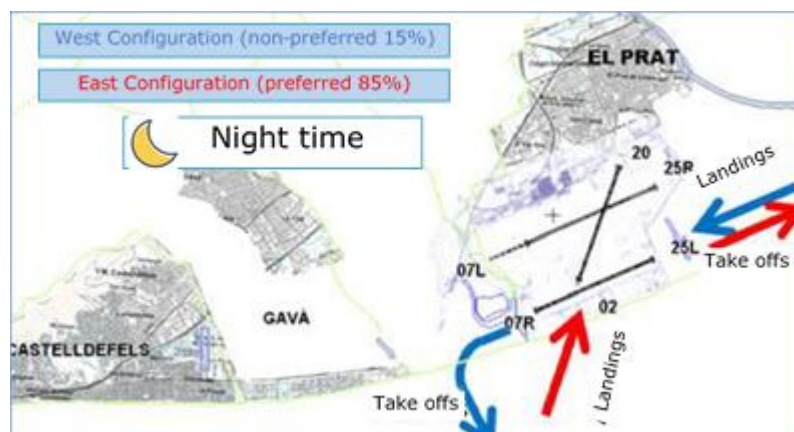
Switching the role of each runway during the day: The longest runway should be used for departures, and the shortest for landings (for safety reasons). The GTTR studied switching the role using the shortest for take-off and the longest for



landings and some take-offs that required more length for take-off (depending of the kind of aircraft).



Night configuration change: Avoided the demolition of the previous cross runway (02-20) and used it during night periods and East configuration with less capacity. Permanently limited the night capacity in Barcelona airport for the West configuration during the night.



When speaking about operational measures, **technical/constructive studies** (radio interference, new runway exit, new access to apron, and so on), **operational studies** (air traffic controller point of view), **capacity studies** (in the air and on the ground) and **environmental/sustainability studies** are required. The technicians had to assess cost/benefit of each option from all perspectives (safety, sustainability, capacity, budget, time frame...).

In this case, from an environmental/sustainability point of view there were:

1. Emissions study: It was a taxi time study associated with capacity ground studies for each option. There was an optimization of it.
2. Noise study: There were three new options to be evaluated against a reference option. Then the study had for each option and for the reference:
 - Daily indicators (Lday, Levening, and Lnight) with people and areas affected (from 75dB till 40dB). It is worth mentioning that all the calculations were done for each configuration (West and East) and

with different fleets, tracks, % of use, and so on, per each period of time (night/day/evening).

- Number of overflights in different points of populated areas and an average of SEL and L_{Amax} in those points. Moreover, the hardest part of the work was taking some working hypotheses and repeat all the calculations for the future horizons 2010 and 2025 like for example:

Operational procedures

Noise abatement flight procedures

- Continuous Descent Operations (CDO), referred to in the past as Continuous Descent Arrival or Approach (CDA); during night hours (between 23:00-07:00), arrival procedures in continuous descent (CDA) are authorized for noise abatement reasons. This procedure avoids the stage flight segments that occur during a conventional landing and has a lower noise impact as well as reduction of fuel and emissions.
- Noise Abatement Departure Procedures (NADP); Published in the AIP and must be followed by all aircrafts, except for safety reasons or air traffic control (ATC) instructions:
 - Take off (RWY 25L): in order to avoid excessive noises at the runway center line extension, the initial turn prescribed in the standard instrument departure (SID) shall begin no later than reaching 500 ft. altitude.
 - Aircraft must follow the nominal trajectory of SID until they have reached 6000 ft., unless they are over the sea, above 3500 ft, in ascent and moving away from the coastline or at more than three nautical miles from the coast and in parallel to it.
- Modified approach angles, staggered, or displaced landing thresholds; some heads of runway have a displaced threshold to allow an increase of the altitude of the flights over the surrounding areas of the airport.
- Low power/low drag approach profiles; According to each aircraft manual for SIDs 25R
- Minimum use of reverse thrust after landing; Reverse use restrictions during night time hours.

The airport has clear opportunities to investigate interdependencies, topic to be developed in T2.5 on airport exemplification case-studies.

10.3.3. Annex B.3.3 Helsinki

Helsinki airport was originally built for the Summer Olympics in 1952. Meanwhile, approximately 1500 companies operate at the airport providing 25000 jobs. Helsinki airport became the largest airport in Finland and the fourth busiest airport in the Nordic countries. About 90% of Finland's international air traffic passes through Helsinki Airport. In 2018 approximately 21 million passengers were handled, including almost 18 million international passengers and 3 million domestic passengers. On average, the airport handles around 350 departures a



day. Two terminals include a total of 29 gates with jet bridges and 80 remote aircraft parking stands.

The airport makes use of three runways. An overview of the three runways is shown in figure B.6.

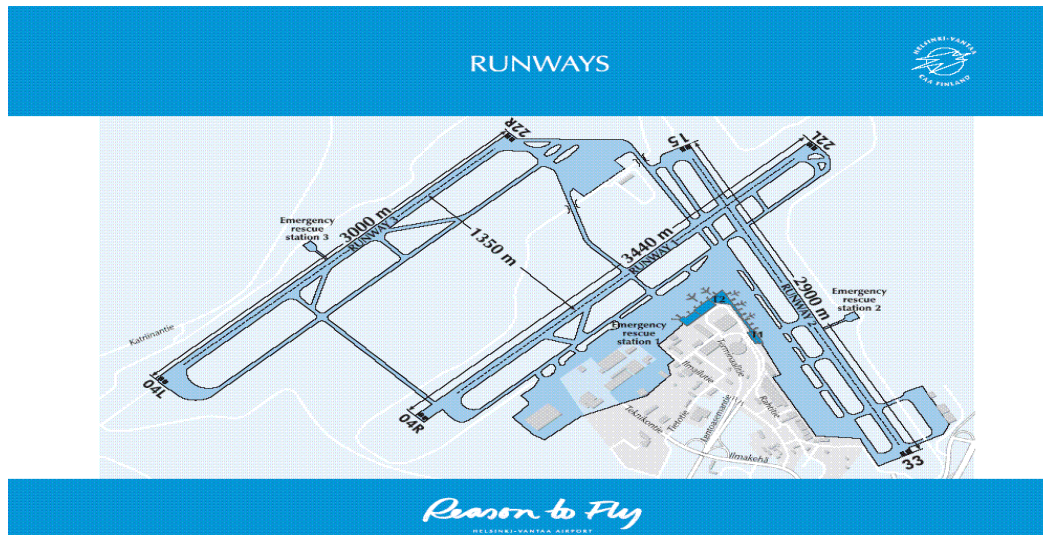


Figure B.6 Map showing the three runways used at Helsinki Airport

Review of NAPs and previous Balanced Approach interventions

In 2015 Finnish Transport Safety Agency, as the competent authority in accordance with the Directive 2002/30/EC, decided on noise-related operating restrictions at Helsinki Airport. Operating restrictions had been requested by an application submitted on the basis of the environmental permit requirement. In its decision Finnish Transport Safety Agency rejected to impose any noise-related operating restrictions at Helsinki Airport as it could not find any ground for them for the time being. The process involved establishment of the noise management objective for the airport and none of the proposed operational restrictions was found necessary for achieving the objective.

Previous BA interventions include **CDO implementation and continuous monitoring of the performance**, NADP1 implementation for runway 22L departures, departure route design minimizing the noise impact to residential areas and noise level restrictions on certain departure routes. In 2017 effective noise abatement strategies for high-weight aircraft were applied in the same way as for low-weight aircrafts. The regulations are in line with the International Civil Aviation Organization's (ICAO) recommendations (Chapter 14).

The departure tracks have been fine-tuned according to the geography and location of suburbs. This has been stepwise implemented during the past 15 years and is meanwhile well optimized. Finavia maintains effective cooperation with Vantaa's local government, which has led to a consensus forming on route-planning and runway use. The runway usage preference principle includes

approximately 20 different combinations. The primarily preferred runway for landings is runway 2 (15) from the northwest.

Identification of any trends and overarching processes and internal systems that underpin BA implementation

A noise area forecast has been included in the Helsinki Region Land-Use Masterplan defining housing restrictions to noise areas. **CEM working arrangement** promotes active co-operation of the major airlines and ANSP to find operationally feasible solutions to **further improve arrival and departure procedures supporting the noise and emissions management**. Noise charges and other economic incentives were implemented to encourage avoiding night time operations and supporting the use of quieter aircraft types.

Introduction to the intervention

Implementing an increased amount of departures at the runway RWY-22L was complex and brought several concerns. One concern was that using the runway RWY-22L more intensively causes that more air traffic will fly over noise sensitive residential areas. Therefore the **noise level based departure procedure** (by ICAO) Noise Abatement Departure Procedure (**NADP1**) was introduced to prevent more intensive noise exposure for the residents. This implies that the airplanes climb higher with constant speed before acceleration is applied. This means that airplanes are flying slower but with higher altitude. The result is a lower noise level due to a higher flight altitude. The altitude difference between NADP1 and Finavia's ("Baseline") regular procedure is schematically sketched in figure B.7.

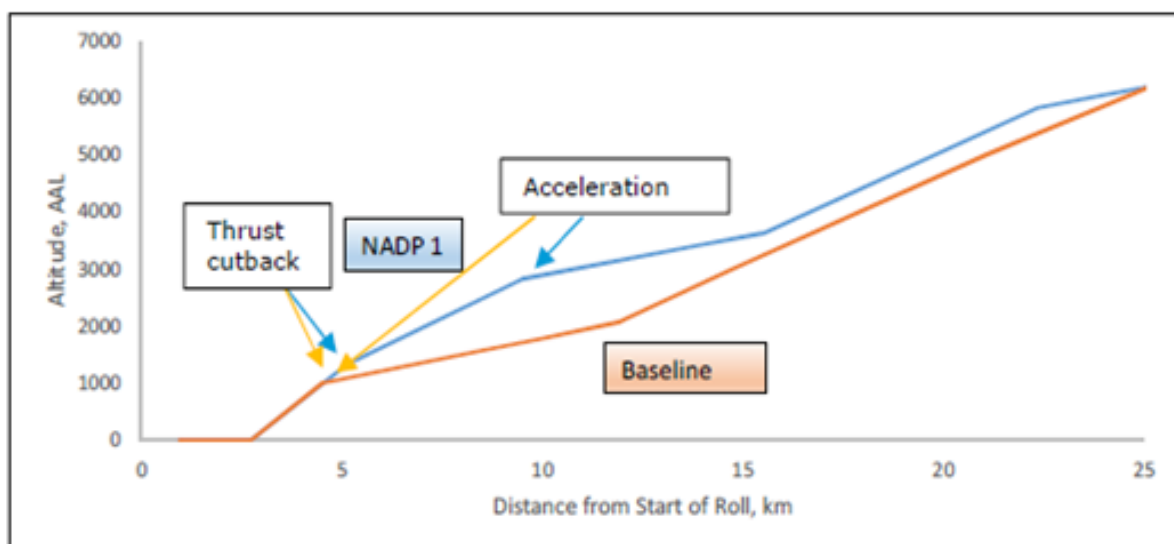


Figure B.7 The NADP1 procedure enabled a reduction of the noise level due to higher flight altitude and longer noise attenuation distances

Exploration the processes behind the case

a. Identification of the 'need'



The departure demand at Helsinki Airport increased during the last years. It was foreseen that the usage of the primary departure runway RWY-22R would reach its limits especially during the afternoon peak hours between 4 pm and 6 pm. Figure B.8 shows the most typical runway configurations at Helsinki Airport.

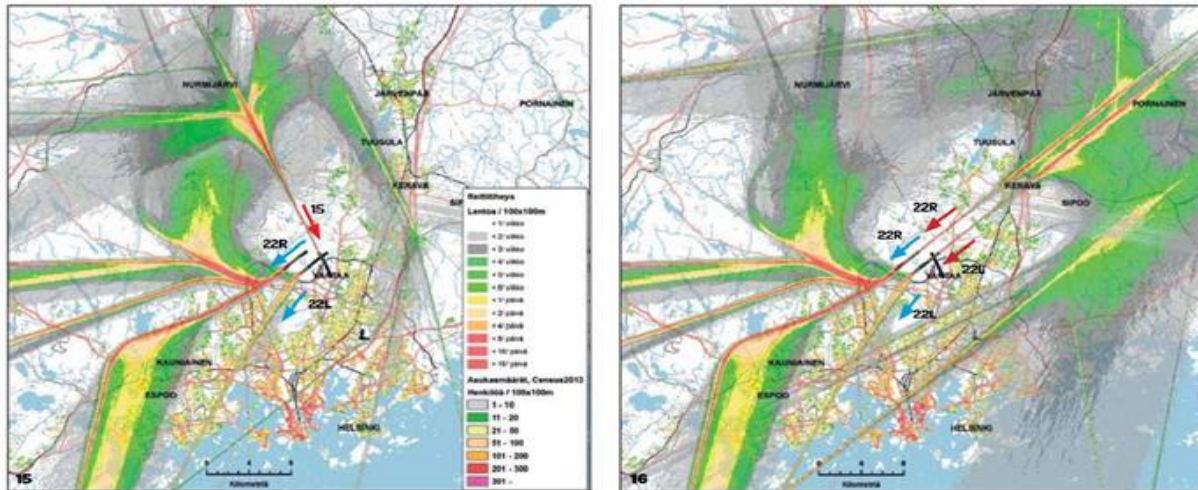


Figure B.8 Typical runway configurations at Helsinki Airport

An additional departure runway was required to handle the increased capacity of aircraft departures. One possible solution to increase the departure capacity was to use runway RWY-22L more intensively within the already implemented noise restrictions. Until April 2018 only one exit point (DOBAN) was used for the traffic to the south. Increased airplane traffic from RWY 22L that fulfilled the security requirements was enabled by splitting the DOBAN exit point into two separate exit points (KOIVU and VALOX), as shown in figure B.9.

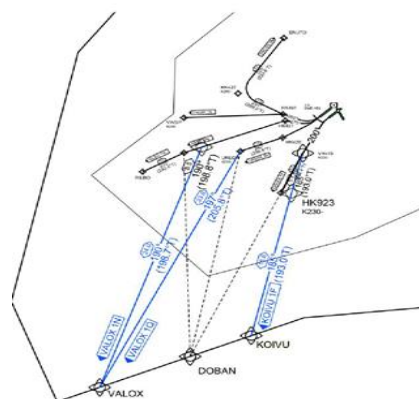


Figure B.9 Splitting the DOBAN exit point into the two separate exit points VALOX and KOIVU

b. The design of options

There was only one option to increase the flight capacity and that was using the runway RWY-22L. The NADP1 departure procedure was chosen as it appeared as the best solution for the populated areas.

c. c. The selection of the intervention

It was expected that the runway RWY 22L would be used more intensively in the future due to the increased air traffic demands. The Integrated Noise Model (INM) was used to calculate the estimated noise abatement for the usage of runway RWY 22L. A flight profile was created for the changed departure procedure. The **estimated noise levels for departures** using runway RWY 22L were compared with the estimated noise levels for the NADP1 departure procedure. A reduction in maximum noise levels (L_{max}) was expected based on the calculations. Measurements proved that the application of the NADP1 departure procedure resulted in a reduction of the L_{max} levels of approximately 3 dB. Summing up, the results for decision making **were less noise exposure and emissions**, less taxi time and air times.

Implementation

The airspace was changed by replacing the exit point DOBAN with two new exit points KOIVU and VALOX. In the same context, the Standard Instrument Departure (SID) route was adjusted to better avoid certain residential areas. The traffic flows are further managed by Estonian Air Navigation Service Provider (ANSP) by using the Route Availability Document (RAD). The airspace changes were planned and implemented in cooperation between ANS Finland (Finnish ANSP), EANS (Estonian ANSP) and Finavia. The RAD was updated by Estonian ANSP as the traffic flows towards south proceed to Estonian airspace after leaving the Terminal Maneuvering Area (TMA). The gradual traffic increase from RWY 22L was enabled by splitting the DOBAN exit point to KOIVU and VALOX points, as shown in figure B.9.

Post-Implementation evaluation

A post-implementation evaluation was not as such carried out. The comparison of multiple track flight departure profiles between Finavia's regular used departure procedure and NADP1 in practice is shown in figure B.10. For NADP1, the aircraft is required to climb with constant speed to a higher altitude before acceleration (green circle) as compared to Finavia's regular procedure (red circle). Reduced noise levels were enabled because the attenuation distance is longer for an aircraft flying at higher altitude.



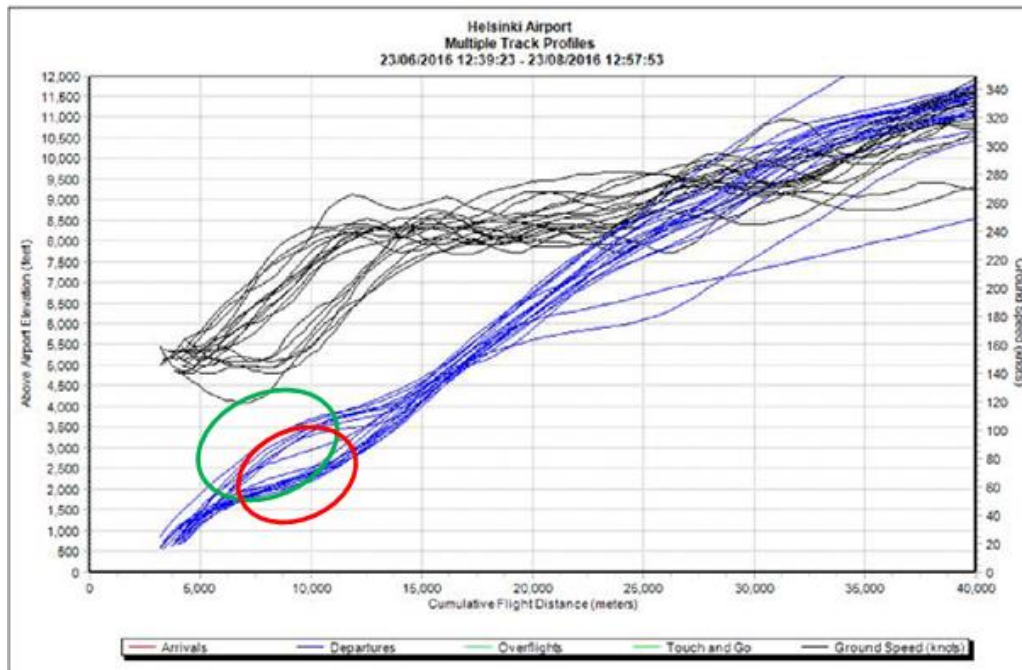


Figure B.10 Departure profile comparison between commonly used departure procedure and NADP1

Summary (of the whole airport case)

Departures were split up between RWY-22L and RWY-22R. This led to fuel, time and emission savings, due to shorter taxi and flight route distances. The safety and capacity situation at Helsinki Airport was improved due to the divided traffic flow. The noise exposure was reduced by **applying the NADP1 departure procedure**. The greatest difficulty was the actual implementation of the changed operational procedure. The avionics data houses did not recognize the changes at the time that the implementation became applicable. The consequence was that the implementation of cockpit charts took extra time and effort. Finavia implemented a note into their flight preparation software to specify departures from the RWY 22L runway. The overall perception of the benefit of the intervention was positive and for the airport and the airlines worth the effort. There was only a small number of noise related complaints from the nearby residential community. The increased number of flight operations has not significantly increased the annoyance of air traffic noise.

In conclusion, the Helsinki case-study is a good opportunity to **assess noise and emissions interdependencies, considering the change in operations**: departures were split up between RWY-22L and RWY-22R. The willingness of the Airport management to engage further with interdependencies will be explored further in T2.5 on airport exemplification case-study.

10.3.4. Annex B.3.4 Schiphol

Amsterdam Schiphol Airport is the main international airport of the Netherlands and located 9 kilometers southwest of Amsterdam. With 71 million passengers in 2018 travelled from, to or via Amsterdam Airport Schiphol it is the third busiest airport of Europe in terms of passenger volume. Schiphol Airport ranks as the world's fifth busiest airport in terms of international passenger traffic and the world's sixteenth busiest for cargo tonnage. The Schiphol Airport passengers increased by 4% in 2018 as a result of an increased number of aircraft movements. The terminal infrastructure consists of one-terminal concept that includes three large departure halls serving local airlines and as a European hub. Schiphol Airport has six runways, covering a total area of 2.79 ha land. The runway use at Schiphol Airport is shown in figure B.11. The red colored flight tracks indicate departures while the blue colored flight tracks indicate take-offs. Schiphol is mainly approached from the North Sea and Flevoland, which is an artificial, low populated island.

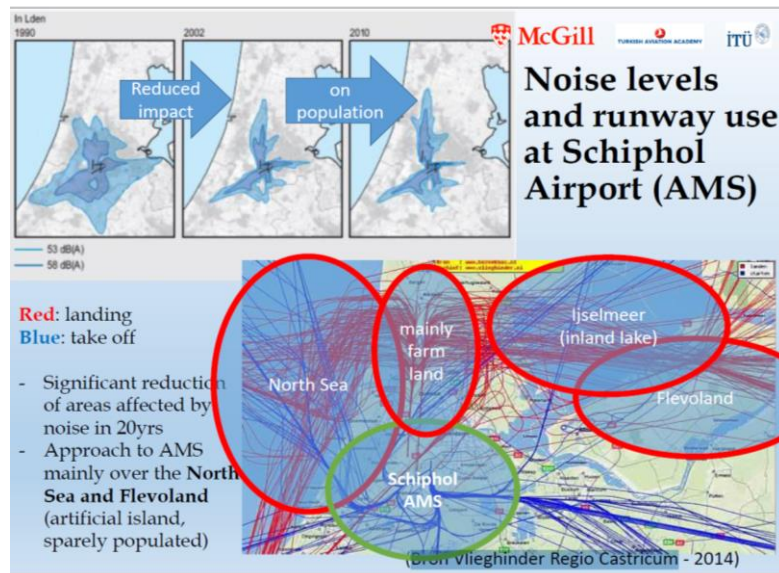


Figure B.11 Runway use at Schiphol Airport indicating flight tracks for departures (red color) and landings (blue color)

Interdependencies and the Balanced Approach

In the Aeronautical Information Publication (AIP) Netherlands are details of regulations, procedures and other information pertinent to flying aircraft described. Currently **applied noise and emissions restrictions** at Amsterdam Schiphol Airport (AMS) are included in EHAM AD 2.21 under noise abatement procedures. The AIP Netherlands includes departure and arrival procedures that have proved to be highly efficient in respect of noise abatement in the vicinity of Schiphol Airport. Deviations from the procedures are permitted for safety reasons. The noise *abatement procedures* are included in table B.4.

Procedure	Explanation

Take-off and climb procedure	National abatement take-off and climb procedure NADP2 recommended for all jet aircrafts departures. If for operational reasons compliance with the recommended procedure is not possible, NADP1 may be used.
Minimum noise routing	Standard instrument departure routes aiming avoid residential areas as much as possible.
Reduced flaps	Reduced flaps landing procedure is recommended
ILS available	Minimum flaps setting with landing gear retracted
Non precision approach and visual approach	Following descent path using a minimum flap setting with landing gear retracted not lower than 5.2° (3.0 degrees), selecting gear down after passing 2000 ft AMSL and postponing minimum certified landing flap setting until passing 1200 ft AMSL.
Use of runways	a) As landing runway: 06, 18R, 36R, 18C, 36C, 27. b) As departure runway: 36L, 24, 36C, 18L, 18C, 09

Table B.4 Noise abatement procedures applied in the vicinity of Schiphol

Further noise restrictions include engine run-up, controlled APU (ground power units), operating quota in effect and a preferential runway system.

Introduction to the case study optimization of start procedures

Noise abatement operational procedures are applied to provide noise relief to communities around airports from both arriving and departing aircraft. Two specific noise abatement departure procedures (NADP's) were developed to mitigate air traffic noise. The **NADP-1 departure procedure** is most effective in confining the noise impact within a small area around the airport. NADP-2 has a distant cross-over point to become quieter than **NADP-1 and is most effective to reduce fuel consumption.**

The differences between NADP1 and NADP2 with respect to the ground and flight speed and the lateral noise exposure is illustrated in figure B.12 below. The noise exposure is shorter due to a higher ground speed when NADP2 is used compared to NADP1 (see point 1 in figure B.12). For the NADP2 departure procedure the flight altitude is lower, which results in a reduction of the lateral noise exposure (see point 2 in figure B.12).

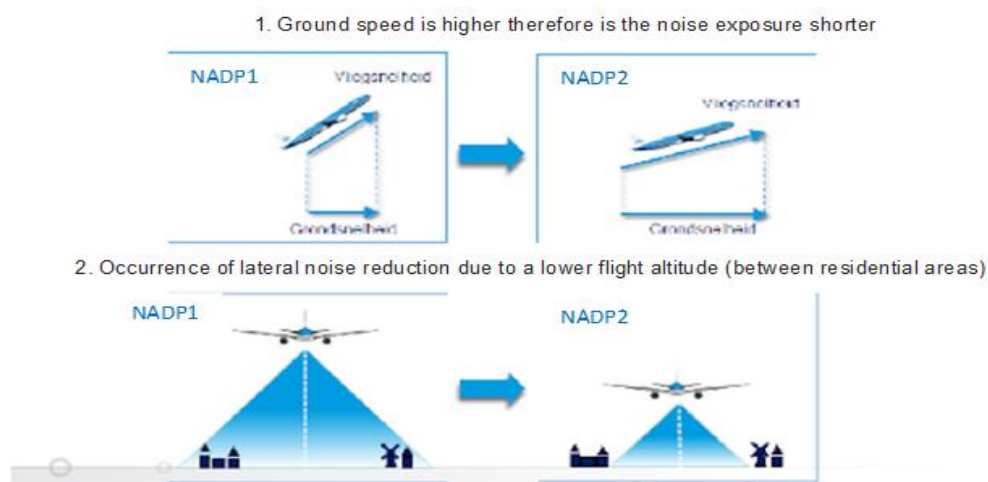


Figure B.12 Comparison of the ground speed and the lateral noise exposure between NADP1 and NADP2

The NADP2 departure procedure leads to a reduction in noise exposure due to a shorter fly over event and a smaller lateral area of exposure, compared to NADP1. The noise abatement departure procedure included a choice between thrust cutback altitude and acceleration altitude

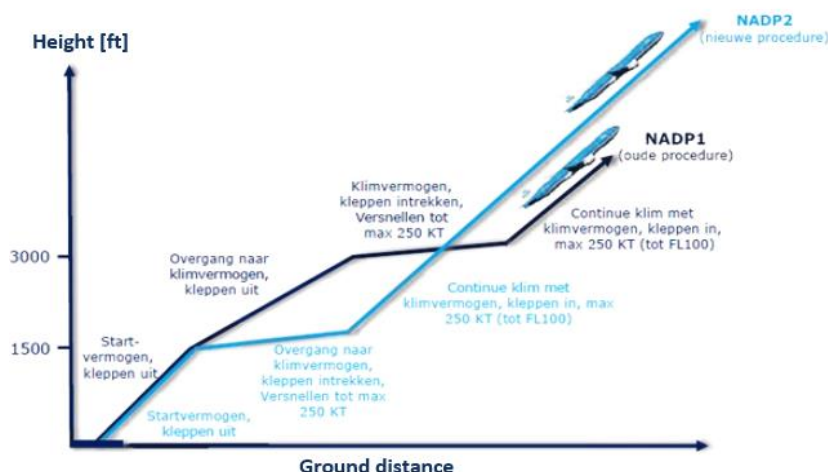


Figure B.13 Illustration of the climb heights between NADP1 and NADP2

The NADP2 procedure starts with a steeper climb where the acceleration required for flaps and slats retraction starts at 1500 ft.

The selection of the intervention

Operations based results, meaning **fuel savings, were used for decision making**. The effect within the noise contours was beneficial too. Hence, both were overall positive and therefore the decision was to recommend this procedure to all airlines. The noise effects were assessed based on the legal criteria for L_{den} and the locally established dose response relationship. Adopting the departure procedures from NADP1 to NADP2 was for Schiphol more a change in an operational procedure than a decision. That is the reason why the communities were informed ahead of time before the departure procedures were changed but they were not directly involved in the decision making process.

Actual noise and fuel consumption measurements

The noise monitoring system (NOMOS) of the Amsterdam Airport Schiphol was used to determine real, measured sound levels of the alternative NADP2 departure procedure. NOMOS consists of a network with more than 25 noise monitoring terminals located in residential areas around Schiphol Airport. Not all 25 measurement terminals were required. The tested runway and route combination together with the relevant NOMOS measurement stations.

In practice it is very difficult to test two departure procedures under the exact same conditions. An experiment was carried out to determine the isolated effect of the NADP2 departure procedure. A number of pairwise comparisons of acoustic measurements between an experimental group of airplanes and multiple test groups were applied.

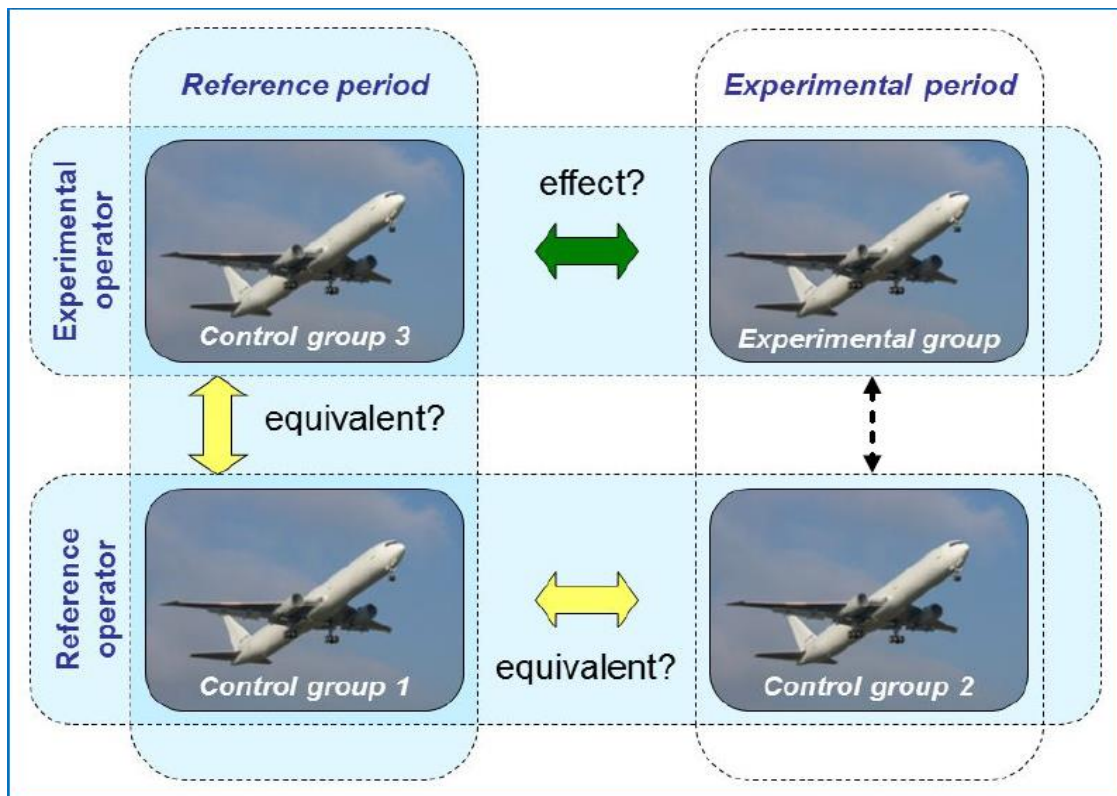


Figure B.14 Schematic presentation of the experimental design

The measurements from the experimental group were compared with three control groups. The likelihood of any difference in noise levels between the experimental group and the control groups was tested using hypothesis testing. The scheme of the experimental design is shown in figure B.14. The relevant comparisons between the experimental and the control group are indicated by green and yellow arrows. The applied pairwise comparisons can provide a qualitative judgment about the likelihood of the effects of the alternative NADP2 departure procedure. However, the influence from external and airline dependent factors cannot completely be eliminated.

Interdependencies

In terms of operational procedures the **priority was fuel consumption**. If changing the departure procedure would have been framed as noise mitigation measure the whole project would have been treated differently and we would have been less independent. The question is at what point is it smart and necessary to involve the local community? Are interdependencies really a matter that the local communities should decide about? It is due to the high amount of critics very important to be careful about how a message is presented and who it is presented to. Schiphol Airport tries to balance everybody's interests in the best possible way, which also applies to for this project.

The benefits assessments for NADP's procedures are complex and may require detailed modelling in order to be well understood. **The results confirmed the expected fuel reduction for the NADP2 procedure.**

10.3.5. Annex B.3.5 Vienna

Vienna Airport is the largest airport in Austria. It acts as a hub for Austrian Airlines, and in 2018 served a total of approximately 27m people (representing annual growth of 10.84%), and over 240,000 aircraft movements. The airport has two run ways (29/11 and 16/34) that are able to operate with no restrictions in terms of aircraft size.

Located 17km west of central Vienna, the airport is surrounded by mostly rural areas but there are a number conurbations in the proximity of the airport, particularly Essling and Groß-Enzersdorf to the North, which are particularly relevant for the below described case study. It is the largest Airport in Austria acting both as a hub for Austrian Airlines and Eurowings, but also as a base for several low-cost carriers.

The airport has three terminals, and two runways which enable the airport to serve large aircraft up to the Airbus A380. Traffic at the airport is forecast to increase, with current capacity expected to be reached in approximately 2025.

In anticipation of growth, the 1998 Master Plan to 2015 detailed a number of expansion projects at the airport. Significantly this included plans for a third runway to help increase airport capacity and to meet demand under the rationale that such growth has significant local socio-economic benefits

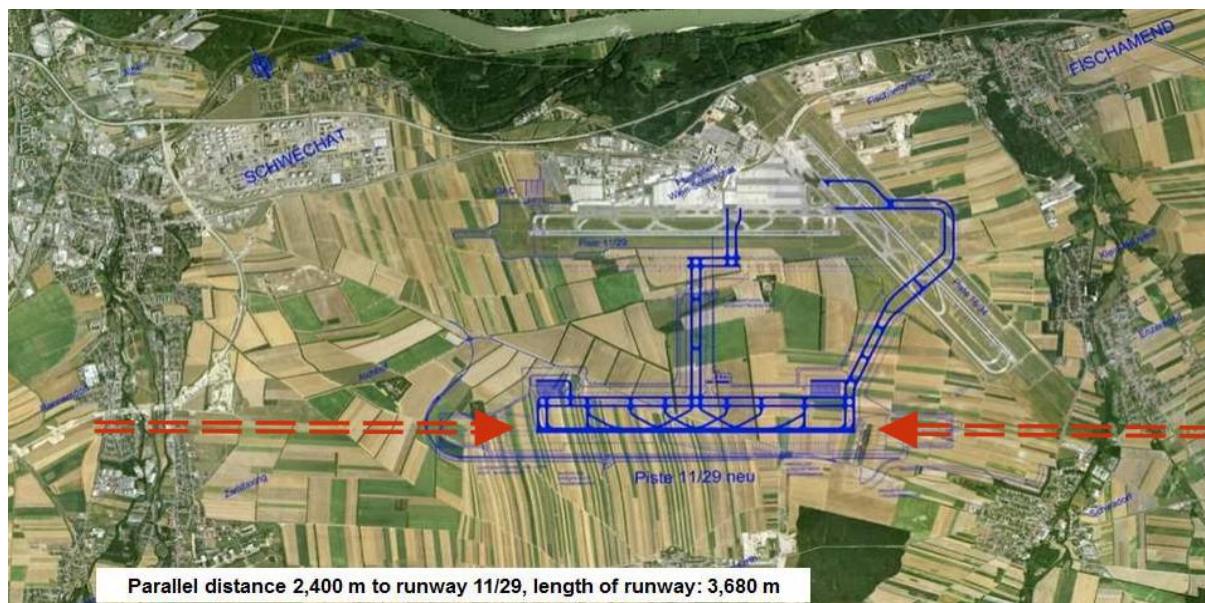


Figure B.15 Proposed location of the third runway

There is no law in Austria regarding airport noise, however noise is a very important issue for Vienna Airport, with the **airport having a considerable noise footprint that includes over two million people**. Noise has been of

concern to the airport since the construction of its second runway in 1972 with opposition to aircraft noise reaching a critical point when the airport announced plans for a Third runway - of which local communities were not consulted. This led to significant conflict with the airport and objections to the runway being given approval.

Today, changes regarding **noise-induced operational restrictions** require the involvement of the Dialogue Forum and its many members, and can only be implemented after an established procedure has been followed. Existing balanced approach measures implemented by the airport are listed in table B.5. The airport **follows a number of operational procedures** designed to minimize noise (and emissions) impact, and these are particularly influenced by the Dialogue Forum. In terms of restrictions these are typically imposed by the responsible administration and not by the airport, however discussions in the Dialogue Forum lead to restrictions in the number of flight movements during night that went beyond legal compliance.

In terms of **operational procedures**, several other agreements were made, notably **minimum noise routes** to avoid overflying communities, and improved flight track procedures, developed through cooperation between the ATC Autocontrol and airlines. Such procedures are regularly reviewed by the Dialogue Forum, with any changes made to SIDs investigated with the airports flight track monitoring system (FANMOS), and results used for further negotiation.

TABLE B.5 Overview of Balanced Approach in Vienna Airport

Operational Procedures	Land-Use Planning	Operating Restrictions
Noise mitigating descent and ascent techniques based on RNP	In the course of the mediation process, the Flughafen Wien AG (Airport Vienna AG) and the neighbouring communities agreed contractually on the abandonment of building land/ housing area in areas, based on the predicted aircraft noise zone of a three runway system, with a L_{den} of 54 or 55, respectively.	Night flight restrictions for single runway directions/ departure routes between 21:00h-07:00h
CDO and CCO when possible	Areas subjected to more than 54dB day and 45 dB night properties can receive between 50%-100% of insulation costs for windows and doors.	Limitation of the number of flight movements during core night time of 4.700/a since 2010. In case of the commencement of a possible 3 rd runway: 3.000/a.
Curved Approach on RWY 16 (testing phase)	Noise absorption measures.	Limitation of APU operating time of max. 30 minutes before take-off/ after landing.
RF-Turns after take-off from RWY 16	Winter gardens constructed in highly noise exposed residences.	
Variable parking positions for engine test runs dependent on the wind		

The Curved Approach- a change in operation

As previously stated, one of the outcomes from the mediation process of the third runway was that it would only take landings arriving on a curved approach. Unlike a standard landing procedure where aircraft follow a long, straight-line landing, the curved approach is a satellite-controlled landing method that sees aircraft swivel in just before the runway and start their approach. The curved approach is a relatively new operational procedure available to the industry. In the case of Austria it had been previously applied at Innsbruck Airport.

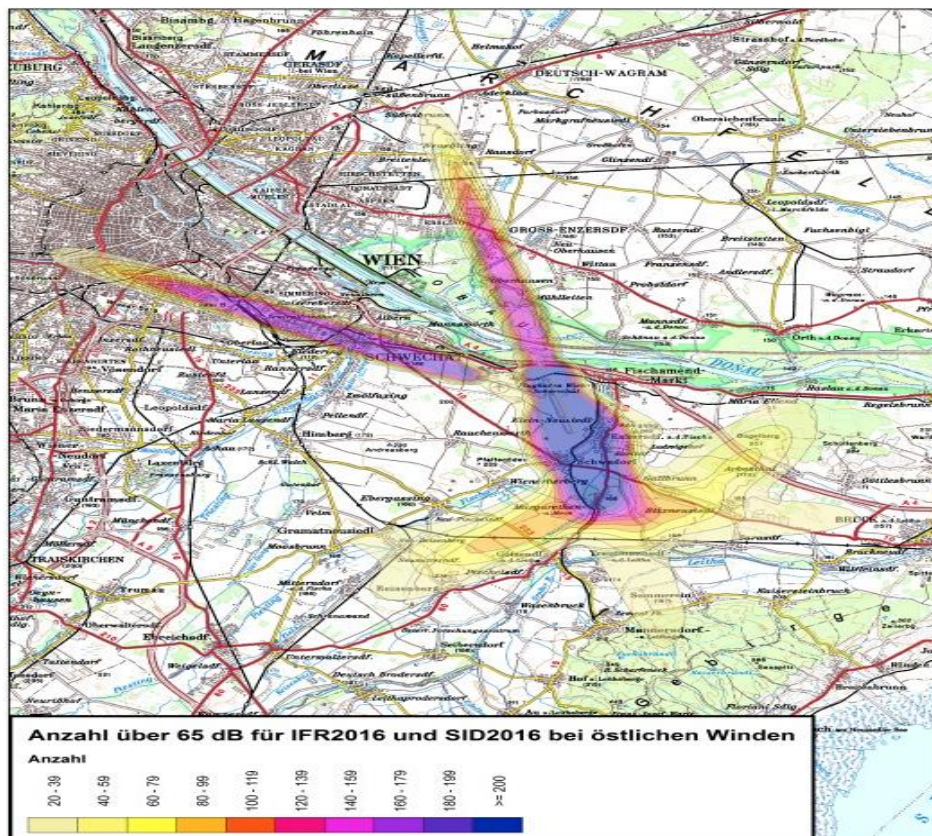


Figure B.16 Proposed curved approach

By including this procedure in the mediation contract, the concept of a curved approach gained much exposure and communities began to enquire if such an approach could be used elsewhere to help avoid overflying currently exposed populations. The call for this operational change was raised to the Dialogue Forum, and it was here that the multi-stakeholder background of the forum in which proposals were reviewed by all communities played a key role

The Dialogue Forum created a Curved approach Working Group in order to find an outcome that would be best suited for all communities. A key consideration of the group is to not transfer the burdens of noise onto others. Thus proposed flight paths were assessed on their ability to fly over uninhabited areas with the aim of noise delivering newly exposed populations.



Through discussions in the Dialogue Forum it was decided (in association with Austro Control) to commence trials to assess the impact of aircraft flying on the curved approach. **Air quality and carbon emissions where not assessed as a priority in these trials as noise is the primary area of concern for communities.**

The airport is considering differential landing charges for those who are not able to fly the curved approach in order to help with the transition to improved technology.

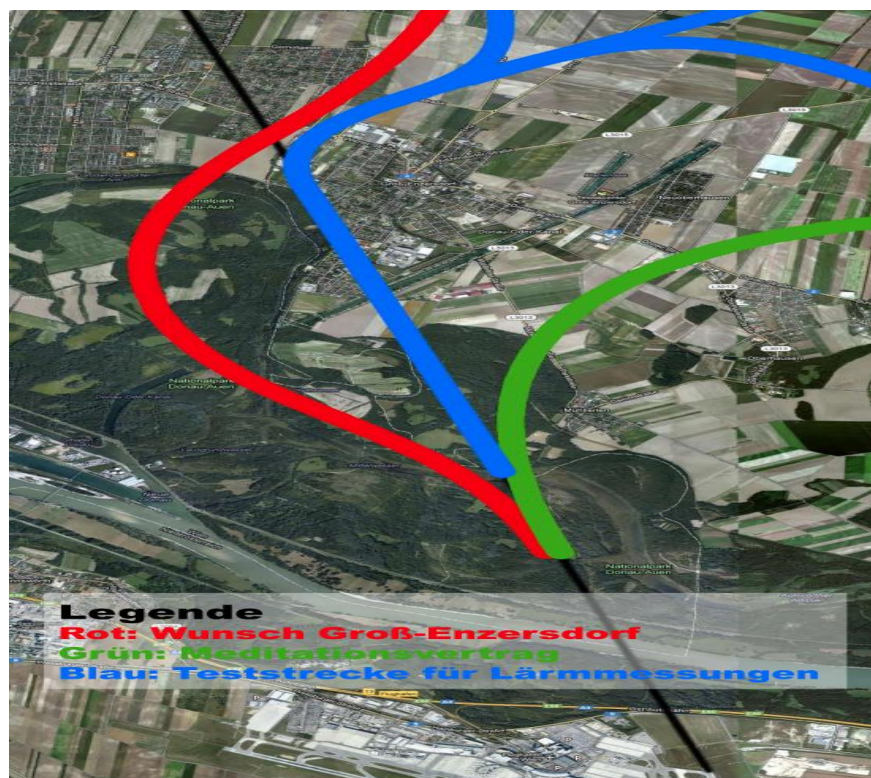


Figure B.17 Options for the proposed curved approach

Noise monitoring terminals were placed along the new flight path and placed symmetrically to assess noise distribution on the ground with one noise monitor placed directly under the flight track and one to either side. Measurements were taken for over 2.5 years – with the time frame determined by obtaining an adequate sample. This required such a long trial as there are significant restrictions on how many aircraft are actually able to use the curved approach. Firstly, the aircraft must have the technical prerequisites to do so. Secondly, pilots must have obtained the appropriate level of training in order to fly this special kind of route. Thirdly the aircraft must be flying from an appropriate direction and with the appropriate winds.

The case study on curved approach needs to explore further the aspect of noise and emissions interdependencies. The T2.5 may be a good opportunity to engage with Innsbruck airport on this topic.

10.4. Annex B.4 Review of metrics and tools

The review of the airport survey data from ST2.3.1 and the below table extracted from ANIMA D2.5 showed that noise metrics were mentioned in all studies. For completeness, table B.6 shows acoustic metrics for all airports of the survey.

The metrics related to emissions are generally expressed in kg or grams. As an illustration: *an **emission intensity** (also **carbon intensity**, C.I.) is the **emission** rate of a given pollutant relative to the **intensity** of a specific activity, or an industrial production process; for example grams of **carbon** dioxide released per megajoule of energy produced*

(<https://fmlink.com/articles/greenhouse-gas-emission-metrics/>)

Airport Study	Case	Acoustic Metrics
	Single Event (at defined receiver points)	Time Averaged (at defined receiver points)
ACNUSA	L _{Amax} – Number above event profiles over time periods and by aircraft groups	L _{aeq} , L _{den} , L _{day} , evening, night. For arrival, departures and total movements
Arlanda	None listed	L _{den} /L _{night}
Barcelona	L _{max} events from noise monitoring stations in 5dB bands for town councils	L _{day} , evening, night. Plus averaged indicators for monitoring stations
Catania	None listed	L _{den} /L _{night}
Cluj	L _{E,A} sound exposure level; L _{p,AS,max} or L _{p,A,eq,1s,max} maximum sound pressure levels	L _{den} / L _{night}
Frankfurt	Continuous SPL, L _{Amax_events} from noise monitoring stations	Measured data for every : L _{eqAircraft} , L _{eqtotal} , L _{DEN_Aircraft} , L _{DEN_total} , L _{DEN} , Maximum level distribution, L _{night}
Heathrow	Single event noise profile	L _{eq} for specific location
Helsinki	L _{Amax} used to identify changes to the routes	None listed
Iasi	L _{E,A} sound exposure level; L _{p,AS,max} or L _{p,A,eq,1s,max} maximum sound pressure levels	L _{den} / L _{night}
Kiev	L _{Amax}	L _{Aeq} day, evening and night
Ljubljana	EPNL for loudest aircraft	L _{day} , L _{evening} , L _{night} and L _{den}
Schiphol	L _{max} used to record measurements from monitoring stations	L _{den}
Vienna	L _{Amax} profiles	L _{eq}

**Table B.6 Noise information matrix –
airport case study use of different noise indicators by type**

Emission metrics

The burning of fuel in the aircraft engine (and APU) results in engine exhaust emissions. Regarding these emissions there are different gasses and particles to consider. For this study CO₂, NO_x and PM emissions are most relevant (see

chapter 5). However, other gasses like HC, CO, H₂O may be of importance too in airport case studies. The mass of gasses exiting the engine exhaust is expressed in kg, g or ton. PM (PM₁₀, PM_{2.5}) is also expressed in these units but ultrafines are often expressed in number and size distribution. Airport emissions may be calculated in different ways depending on the intended use of the data. A common way is to calculate emissions for the so called Landing and Take-Off (LTO) cycle. This cycle is used in engine certification, but can also be used for emission inventories at airports in which case the so called time-in-modes may be adapted to the specific airport. Another option is to calculate emissions from ground level up to – for instance - 300m⁹³ when considering local air quality and the impact of emissions on the community.

Figure B.18 shows an example of how emissions may be presented when considering the introduction/change of a procedure.

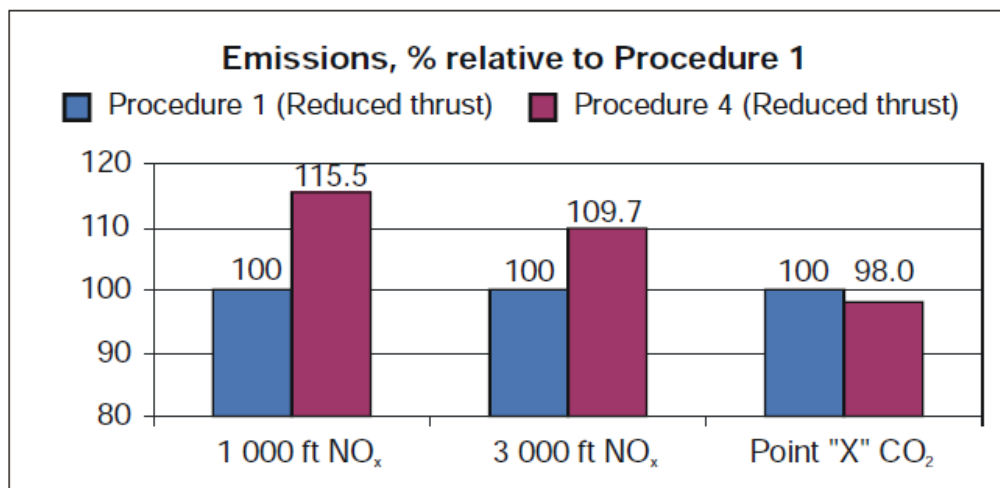


Figure B.18 Example of comparison between the emissions of two departure procedures⁹⁴

Noise metrics

A variety of noise metrics is available from literature. The various metrics found can be classified according to table B.7.

⁹³ Above 300m emissions have little impact on local air quality.

⁹⁴ Source : ICAO Circular 317 « Effects of PANS-OPS Noise Abatement Departure Procedures on Noise and Gaseous Emissions »

Type	Single-event	Multi-event
Instantaneous	LA, LC, LZ, PNL, PNLT	-
Maximum levels	LA _{max} , LC _{max} , LZ _{max} , PNLT _M	-
Integrated	LA _{eq} , LC _{eq} , LZ _{eq} , EPNL, SEL _A , SEL _C , SEL _Z	Lden, Lnight, DNL, LA_{eq,1h,ac}, LC_{eq,1h,ac}, LZ_{eq,1h,ac}, LA_{eq,1h} Flight Noise Level
Contour related	-	Contour Area Contour aspect ratio
Time related	Time Above Threshold Time Audible	Time Above Threshold, Percentiles, Time Audible, Noise Free Interval
N° events related	-	Number Above Threshold N° audible events
Population related	-	Person Events Index Average Individual Exposure

Table B.7 Classification of metrics

Each of these metrics has their application domain. For environmental studies usually A-weighted metrics are used. When comparing e.g. different departure procedures, a single-event noise level as a function of distance might be a good metric (see e.g. figure B.19).

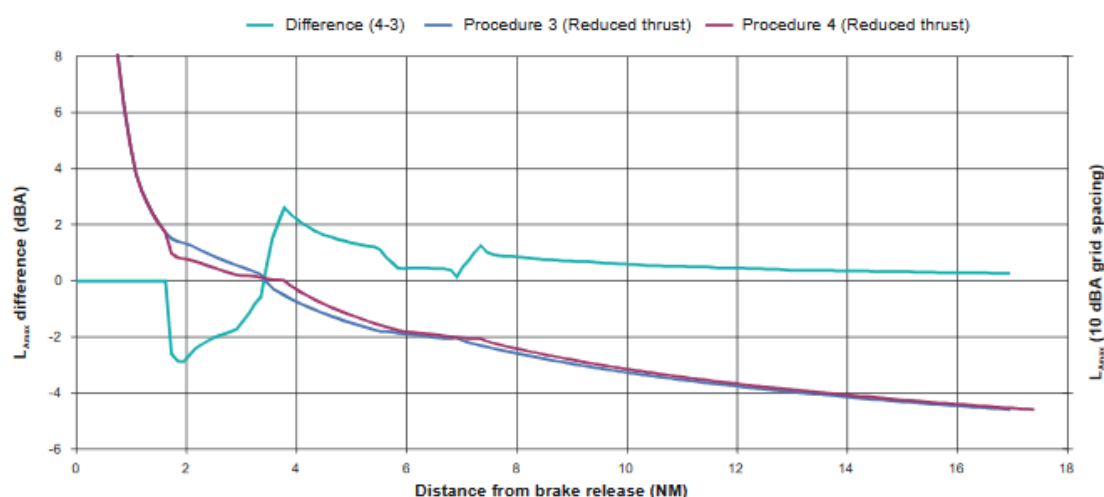


Figure B.19 Example of comparison between the noise of two departure procedures⁹⁵

Tools

In essence airports often use their own tools/contracts out to specialists who use single issue tools – e.g. noise modelling and air quality modelling. But these may make various assumptions which could be in conflict.

The airport survey did show that the noise tool (INM) was used in the Heathrow and Helsinki cases. However, review of the received documentation did not show the use of a tool that could calculate both noise and emissions.

⁹⁵ Source : ICAO Circular 317 « Effects of PANS-OPS Noise Abatement Departure Procedures on Noise and Gaseous Emissions



Organisation	Tool for		Notes
	Noise	Emissions	
ANOTEC	SONDEO	SONDEO/EM	Batch capability
EUROCONTROL	IMPACT/STAPES	IMPACT	Batch capability Incl. LAQ
FAA	AEDT/INM	AEDT/EDMS	Incl. LAQ
NAU (Kiev)	ISOBELLA	POLEMICA	Incl. LAQ
NLR	TUNA	LEAS-IT	Incl. LAQ
University Roma Tre	-	FRIDA	

Table B.8 Identified noise and emissions tool suites

In a study under a contract from DG-MOVE⁹⁶ several ANIMA partners (NLR, DLR, ANOTEC) reviewed the existing models for aviation environmental impact assessments. Whereas many organisations have developed stand-alone tools for noise **or** emissions calculations, only a few have available tools that can handle noise **and** emissions in a consistent and integrated manner, e.g. by using the same input data environment. Table B.8 provides the list of tool suites that were identified in this study.

Tool description:

SONDEO

Developed by ANOTEC, the SONDEO model can estimate noise contours surrounding an airport, as well as the number of people exposed within that contour. The noise contour module (NCM) calculates noise contours for a variety of noise metrics according to ECAC Document 29 (4th edition). The population module is capable of overlaying the noise contours from NCM on population maps, so as to determine the number of people exposed to certain levels of noise. From the total number of people exposed, the percentage of highly annoyed people may be derived. The EM module has been added to SONDEO in order to estimate emissions for the same traffic and route scenario as used for noise. Emissions are calculated based on the fuel flow and emission indices of the ICAO Aircraft Engine Emissions Databank for turbofan and turbojet engines, the FOI database for turboprops and the FOCA database for piston engines. Both the ICAO LTO (TiM) and Boeing FFM2 methods have been implemented to calculate fuel burn, CO₂, CO, HC and NO_x emissions. PM emissions can be calculated based on the First Order Approximation v3.0 (FOA3). SONDEO can be executed for a single airport or for a batch of airports to facilitate regional/global assessments.

IMPACT

Within the context of the SESAR Research and Innovation programme, EUROCONTROL has developed IMPACT, an integrated aircraft noise and

⁹⁶ Design of a Publicly Accessible Aviation Tool Suite Report ; Deliverable D1 in the framework of Service contract No. MOVE/C2/SER/2014-269/SI2.706115 for the development of a Public European Model Suite for Aviation – Jan.2016

emissions modelling platform that supports both aircraft noise and fuel burn/emissions assessments⁹⁷.

AEDT (INM & EDMS)

In the United States the Aviation Environmental Design Tool (AEDT) ⁹⁸ is used to model aircraft performance in space and time to estimate fuel consumption, emissions, noise, and air quality consequences. Such computations can take place on a range of levels, from a single flight at an airport to scenarios at the regional, national, and global levels.

ISOBELLA/POLEMICA

The **IsoBella** model has been designed in National Aviation University (NAU), Kyiv, Ukraine, for calculation of noise levels/indices at specific points and/or noise contours (for a number of types of level/indices) for airport flight scenarios under consideration. IsoBella is fully compliant with the airport noise contour modelling methodology described in ICAO Document 9911 and meets the ECAC requirements from Doc 29 3rd Edition.

POLEMICA

POLEMICA (Pollution and Emission Calculations) is a modelling system for the calculation of airport-related pollutant emissions and air pollution in the lower atmosphere. The tool was developed by the National Aviation University (NAU), Kiev and is currently under the evaluation by ICAO/CAEP/MDG (Modelling & Database Group).

Main purpose of the PolEmiCa is to provide the dispersion (Pollution) and inventory (Emission) calculations for the aircraft engine emission during the landing and take-off (LTO) cycle of the aircraft movements inside airport area. Besides LTO stages of flight it includes the aircraft emission from aircraft engine start-up procedures, APU and GSE also. Current version of the PolEmiCa combines the calculation for the main stationary sources of the emission and road vehicles inside airport area with character matters for aircraft engine emission: CO, HC, NO_x, SO_x, PM and fuel vapours (HC).

TUNA/LEAS-iT

TUNA (by NLR) is a model which assists parties to calculate noise contours in accordance with ECAC Doc 29, hence supporting airport management, local authorities and residents in evaluating development plans, traffic scenarios and different flight procedures. While TUNA is a stand-alone model it can share its input with NLR's LEAS-iT (emissions) and TRIPAC/GEVERS (third party risk) models. Model outputs are Noise grid and or contours in metrics like LDEN,

⁹⁷ <https://www.eurocontrol.int/sites/default/files/service/files/2014-IMPACT-factsheet.pdf>

⁹⁸ <https://aedt.faa.gov/>



LNIGHT, LAMAX, SEL, etc., as well as the number of houses or number of residents within the noise contours. Required as inputs are scenarios like number of aircraft movements per year specified by aircraft type, flight phase (take-off/landing), runway, and flight procedure (flightpath).

LEAS-iT

LEAS-iT Local Emissions (around) AirportS inventory Tool is an advanced tool capable of analysing and assessing the various aircraft emissions, in space and time, at and around the wider vicinity of airports. The emissions are based on the airport and runway layouts and are sensitive to operational procedures and routes, traffic, and aircraft performance and emissions properties. Both airborne and ground operations can be modelled. LEAS-iT can handle different types of fuel e.g. Jet-A1, Avgas. The model's outputs are detailed air traffic fuel use and emissions (amongst others: CO₂, H₂O, NO_x, PM₁₀, lead, unburnt hydrocarbons) in 3D-grid and hourly dimensions, both ground and airborne operations.

10.5. Annex B.5 Review of pressure from competing environmental agendas

In the case of Heathrow a stepwise process has taken place in which the community request was partially fulfilled. The community wanted a steeper profile, however this was informed by incorrect information on what other airports were doing and what was operationally feasible. Heathrow did the maximum slope they thought was possible. It is good practice as it was a community request that was acted on by the airport – the airport just couldn't go to the same distance as the communities wanted due to interdependencies (safety / emissions). In the Helsinki case the community was not directly involved in the decision-making process. Also in the Schiphol case the community was not directly involved in the decision making of the project but it was informed well ahead of time. In Vienna stakeholders - including the community - were consulted with regards to change in operations.

10.6. Annex B.6 Decision making process

Interdependencies between noise and emissions in the aviation sector are multifaceted and should be considered in aircraft/engine design decisions, operational decisions and regulatory decisions.

Examples of each type of these decisions are:

- When comparing open rotor and the turbofan designs fuel burn and noise characteristics must be carefully evaluated
- When introducing a (change in) flight procedure noise levels - depending on the specific area considered - may decrease or increase in communities around the airport.
- Regulatory noise limitations may have the potential to increase emissions.

Having the required knowledge in making the best decision is not an easy task.

These decisions may impact more global (en-route) aircraft operation but also more local airport operation. Since the airport is central in the description of work of ST2.3.3 this Annex addresses airport operations and decision-making by the main stakeholders involved in selecting local procedures to achieve noise and/or emissions reduction. Since it is not possible to address all specific cases for each and every EU airport and, furthermore, in most cases the required level of detail⁹⁹ of data will be absent to address these cases in detail, this chapter provides a more qualitative approach. This Annex is meant to inform about and to raise awareness of a range of possible measures and its implications on noise, NO_x and CO₂ emissions.

Regarding emissions historically NO_x and CO₂ have been important. More recently PM is becoming too (see also Annex A). A significant knowledge gap in environmental studies is the amount of PM actually produced during aircraft operations. The PM emissions are (often) calculated with methods that are based on measurement data with a high degree of uncertainty¹⁰⁰.

This means that PM emissions in airport environmental studies, including the ones on the impact of (a change in) aircraft operations, are also calculated with a high degree of uncertainty, if they are calculated at all. For this reason Annex B addresses the interdependencies and trade-offs between noise, NO_x and CO₂ emissions as effect of aircraft operation changes and does not address the interdependencies with PM emissions.

⁹⁹ For instance, FDR data may be lacking when considering flight procedure changes and their effects.

¹⁰⁰ Annex A provides more information on the latest developments regarding PM (including ultrafines) measurement and modelling.

