Sustainable Airport Solutions

Noise Abatement

A GSA Baseline Study

GSA


RYANAIR
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Content

Abbreviations

A/C	Aircraft
ACDA	Advanced Continuous Descent Approach
AIP	Aeronautical Information Publication
AOM	Aircraft Operation Manual
APU	Auxiliary Power Unit
ASDA	Acceleration to Stop Distance Available
ATC	Air Traffic Control
CAA	Civil Aviation Authority
CDA	Continuous Descent Approach
dB	Decibel
EDDM	Airport München
EDDR	Airport Saarbrücken
EDDW	Airport Bremen
EDOP	Airport Schwerin-Parchim
EGMC	London Southend Airport
EHGG	Groningen Airport
EKBI	Billund Airport
ENTO	Sandefjord Airport, Torp
GPU	Ground Power Unit
IFR	Instrument Flight Rules
ILS	Instrument Landing System
kt	Knots
LDA	Landing Distance Available
L_{eq}	Continous Sound Pressure Level in dB
LM	Landing Mass
LW	Landing Weight

MTOM	Maximum Take Off Mass
MTOW	Maximum Take Off Weight
PIC	Pilot In Command
Temp	Temperature
TODA	Take Off Distance Available
TOM	Take Off Mass
TORA	Take Off Run Available
VFR	Visual Flight Rules

1 Introduction

Green Sustainable Airports (GSA) is a project designed to make regional airports sensitive in sustainable development and growth. It aims to establish strategies and solutions for a more eco-efficient and green regional aviation industry. In a multi-national partnership, the project focuses on regional airport communication, regional cooperation and policy resolutions to safeguard the role of regional airports as accessibility gateways by improving public perception and acceptance. As a major objective, GSA tries to conciliate all stakeholders´ interests.

Based on the above mentioned an additional meeting on 11th and 12th of May 2011 took place in Bremen. The results were presented in a discussion paper prepared by Mr. Krüger, Bremen Ministry of Economic Affairs, Labour and Ports. The discussion paper was circulated to all members of the project for additional input. Remarks from m2p, Billund Airport and Kortrijk Airport were considered as well as research and expertise contributed by UNICONSULT universal Transport Consulting GmbH and airline contacts. The preliminary results were presented in a Power Point Presentation on 6th of October 2011 during the GSA partner meeting in Kent (Annex 1).

2 Noise from Aircraft Ground Operation

2.1 Taxiing

2.1.1 Actual Situation

While taxiing from the apron to the runway before take-off or vice-versa after landing aircraft engines emit noise into the vicinity. Depending on the location of the taxiways and frequency of their use these emissions may cause short-time (< 1 min) but frequent annoyances in nearby residential areas.

2.1.2 Possible Solutions

a) Noise protection walls

One possibility mentioned during the discussions was to establish protection walls along the critical taxiways. The use of fixed barriers (concrete or steel) will reflect the noise and the result is a dislocation of the problem. This problem came up at Saarbrücken Airport (EDDR) after installation of a noise protection wall in the vicinity. With special absorbing material, or construction (dispensation of the sound pressure) it is possible to improve the effectiveness of such constructions. As a physical principle the effectiveness of a protection wall will decrease with the distance of the noise source. The physical requirement to get close to the noise source is contrary to the ICAO Annex 14 requirements. According these regulations taxiways must have an obstacle free area depending on the airport code number (Figure 1, Column (11).

Some airports planted hedgerows along critical residential areas. From the scientifically point of view hedgerows will decrease the noise level up to 3 dB, but a tremendous width is necessary to reach this target. Nevertheless the involved airports have good success with these hedgerows, because there is also a psychological effect included.

Table 3-1. Taxiway minimum separation distances

Code letter	Distance between taxiway centre line and runway centre line (metres)								Taxiway centre line to taxiway centre line (metres)	Taxiway, other than aircraft stand taxilane, centre line to object (metres)	Aircraft stand taxilane centre line to object (metres)
	Instrument runways Code number				Non-instrument runways Code number						
	1	2	3	4	1	2	3	4			
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
A	82.5	82.5	–	–	37.5	47.5	–	–	23.75	16.25	12
B	87	87	–	–	42	52	–	–	33.5	21.5	16.5
C	–	–	168	–	–	–	93	–	44	26	24.5
D	–	–	176	176	–	–	101	101	66.5	40.5	36
E	–	–	–	182.5	–	–	–	107.5	80	47.5	42.5
F	–	–	–	190	–	–	–	115	97.5	57.5	50.5

Note 1.— The separation distances shown in columns (2) to (9) represent ordinary combinations of runways and taxiways. The basis for development of these distances is given in the Aerodrome Design Manual, *Part 2.*

Note 2.— The distances in columns (2) to (9) do not guarantee sufficient clearance behind a holding aeroplane to permit the passing of another aeroplane on a parallel taxiway. See the Aerodrome Design Manual, *Part 2.*

Figure 1, ICAO Annex 14 Part1 Chapter 3 (excerpt)

Figure 1 above describes the necessary distances between an obstacle and the taxiway centreline (column 11). The distance is depending on the airports code number.

b) Taxiing with one engine off:

This procedure is feasible for all turbo prop aircraft, because the electrical and hydraulic systems are therefore configured. This procedure is not recommended for jet engine aircraft though. To start the second engine it is necessary to run the auxiliary power unit (APU) the whole time. It is also possible to start the second engine using air from the first engine but the disadvantage of doing this outweigh an possible fuel savings or noise reduction (has to be performed on a high idle powersetting).

2.2 Aprons / APU-GPU / Engine Start-up

2.2.1 Actual Situation

While standing on the apron an aircraft requires electrical power to supply aircraft systems needed for handling and turn-around. Electrical power is usually delivered by auxiliary (APU) or ground power units (GPU) whereas APUs are much more noisy than GPUs. Depending on location of the aprons these emissions can cause long-lasting (> 30 min) annoyances in nearby residential areas.

2.2.2 Possible Solutions

a) Use of ground power units, electrical power and pre-conditioned air supply

Aircraft stands have to provide electrical power and preconditioned air (cooling, heating, ventilation) for the avoidance of using an APU. If both sources are available the use of the APU can be minimized to a few minutes before starting the engines. To minimize the noise and carbon-dioxide emissions it will be helpful to use the public electricity network, with an additional transformer, instead of Diesel engine driven ground power units (GPU). The fuel consumption of a medium sized APU (Boeing 737, A 320) is about 100 litres JET A 1 per hour. Modern GPUs are consuming about 36 litres Diesel per hour.

Figure 2 is showing an under floor power supply station, driven by the public electricity network with an additional transformer to generate 115V/ 400Hz. This equipment is mainly used for maintenance purposes. Figure 3 and 4 are showing the electrical and preconditioned air supply mounted on a boarding bridge. Both are working without additional engine driven facilities. If both sources are available it is only necessary to use the APU for starting the engines, because jet-engines need pneumatic pressure for the starter.

Figure 2, Under floor Power Station

The power supply station shown in figure 2 can be installed as an under floor equipment at the apron as well as in maintenance hangars. In addition to the necessary 115V/400Hz supply for aircraft it can be also used for electrically driven conveyor belts and illumination of working environment, because other voltages and frequencies are available. A folding mechanism is installed to close the supply station and therefore guarantees a smooth surface to avoid accidents and mishaps.

Figure 3, Preconditioned Air Supply mounted on a Gangway

Figure 4, Connection Point for preconditioned air at the lower fuselage

As mentioned before for the avoidance of using an APU it is necessary to supply the aircraft with electrical power and preconditioned air. During summertime it is not only necessary for cooling the cabin for passenger comfort but also for cooling the electric and electronic compartment of the aircraft. In this compartment the sensitive flight computers are installed. During wintertime the preheating is necessary for the avoidance of water condensation.

Figure 5, Electrical Power Supply (Gangway)

An alternative to under floor power supply stations is to install the electric power supply directly below the gangway as shown in figure 5. The grey box under the bridge is housing the transformer for the necessary 115V/400Hz supply. The transformer is driven by the local electricity network. To avoid additional traffic and pollution on the apron it is helpful to use existing sources instead of running additional engine driven GPU or the APU.

b) Limitation of APU use

A limitation of the APU use of 5 Minutes before off-blocks is an appropriate instrument to avoid additional pollution. Airlines and airports have the same targets in this case, because with each APU-cycle and operating hour the maintenance cost and fuel consumption will increase.

2.3 Engine test runs

2.3.1 Actual Situation

a) Especially piston engine aircraft have to perform a so called “run-up” before take-off, mostly at the taxiway holding position near the runway intersection, to check aircraft systems and engine function at medium (normally not maximum) power setting. Depending on location of the runway holding positions these emissions can cause short time (< 5 min) annoyances in nearby residential areas.

b) If available at the airport, it may be that local aircraft maintenance companies perform engine test runs for maintenance purposes, e.g. compass calibration or system checks after engine change. Depending on designated locations for the test runs these emissions can cause long time (> 30 min) annoyances in nearby residential areas.

2.3.2 Possible Solutions

a) Selection of a not sensitive area for engine test-runs

The easiest measure to reduce noise is to select an area of the airport for test runs that is not very noise sensitive. This measure is useful when no or not much extra noise is produced due to taxiing with the aircraft’s own engine power.

b) Noise protection walls

Run ups for piston engine aircraft are part of the preflight check and must be performed but not necessarily at the end of the taxiway. This procedure is especially with constant speed propeller a long lasting event. There could be an area with noise protection walls where run-ups can be performed before the Aircraft is taxiing to the holding point at the runway intersection. Engine test runs are necessary and mandatory for jet- and turbo-prop engines after certain maintenance events e.g. filter changes, trouble shooting.

Figure 6 is showing a noise protection hangar which can accommodate a Bombardier Dash 8 or ATR 42 used after maintenance events for engine test runs. This hangar is along a taxiway and can also be used for pre-flight checks with piston engine aircraft.

Figure 6, Noise Protection Hangar (U-shaped), Investment € 1,5 Mio

This construction is closed on 3 sides (U-shaped) and can accommodate Dash 8 and ATR 42. Due to the width of the rear area it can be used for piston engine aircraft as well without any pushback or additional help for the preflight checks and engine run ups. The tops of the sidewalls have additional deflectors for further noise reduction.

c) Time restrictions for test runs

Time restrictions for test runs can be a suitable instrument to avoid noise during sensitive times. Especially for airports with home carriers and regular flights the time restriction has to take the normal airports operating hours into account. Otherwise additional hurdles for their home carrier (maintenance during night, test run before the first flight) will be set up.

d) Use of a push back tractor for compass calibration

For the compass calibration the aircraft has to be turned several times in different directions. This can be done with the own power of the aircraft or with a tractor that is used for moving aircraft on the ground. In general the vehicle needs less fuel and does not produce as much noise as the aircraft engines.

Even in the case that aircraft engines are running (in order to produce magnetic fields like in flight) the noise can be reduced due to engines running with “idle” power setting. The noise would be higher when the aircraft turns with its own power. This requires a higher power setting than “idle”.

2.4 Push back

2.4.1 Actual Situation

The exact location where the engines are started before departure has significant influence on noise emissions.

2.4.2 Possible Solutions

Recommendation:

It is under the control of the airport where the aircraft is pushed for starting the engines. To avoid additional annoyances the push-back of the aircraft should be performed in areas which are not noise sensitive. Cross- and tailwind limitations are given from the engine manufacturer depending on the aircraft type (25 kt is a common value).

3 Noise from Aircraft Air Operation

3.1 General

3.1.1 Actual Situation

Aircraft in the air produce emissions that in the worst case come from above and cannot be mitigated by noise protection walls or barriers.

3.1.2 Possible Solutions

a) Administrative regulations:

- Airport charges depending from noise emissions
- Quota Count (Noise Contingent)
- Night flight restrictions
- Restrictions for training purposes
- Ban of certain Aircraft Types

b) Financial tools:

- Penalties for delayed flights
- Additional charges for night or late arrivals
- Additional fees for exceptions
- Refunds for improved noise abatement procedures

c) Passive noise protection:

- Refunds for noise protection investment (e.g. windows)
- Refunds for relocations

The above mentioned possibilities are all political instruments to avoid noise in the vicinity of these airports. The economical impact of using such instruments has to be calculated and agreed by the Airport Authorities, Airport Operators and Shareholders. The needs of the aircraft operators, public and other concerns (e.g. impact on regional economy) should be taken into account.

3.2 Departure Procedures (lateral – vertical profiles)

3.2.1 Actual Situation

When taking off and departing aircraft need to apply full or nearly full power, which in each case causes short time (< 5 min) but high level emissions and annoyances not only in the area beneath the flight track, but also in the areas beside it.

3.2.2 Possible Solutions

a) Thrust reduction: Calculation of power setting for take off

Since a couple of years airline standard is to set the lowest take off power in comparison with the available Take Off Distance Available (TODA), Take Off Mass (TOM), temperature, barometric pressure, obstacle situation and runway conditions. At the same airport each day another power setting is used. The actual TOM is the major determining factor. The calculation of the power setting is a standard procedure for most parts of commercial aviation. Further noise reduction is possible when such procedures are used for example for General Aviation flights as well. Precondition is the availability of tools for the calculation of the power setting.

b) Thrust reduction after take off

After take off a lower power setting is necessary for the climb to the cruising altitude. The power setting can be reduced when the aircraft reached a sufficient distance from obstacles on the ground. The German AIP (Aeronautical Information Publication) recommend a thrust reduction at an altitude of 1500 feet above ground (see excerpt German AIP: figure 8). Further noise abatement would be possible if similar rules were established for airports (outside Germany) that do not yet recommend a thrust reduction.

Figure 7 shows the measuring points for the certification of aircraft noise emissions according ICAO Annex 16 Chapter 3 and the climb path after thrust reduction.

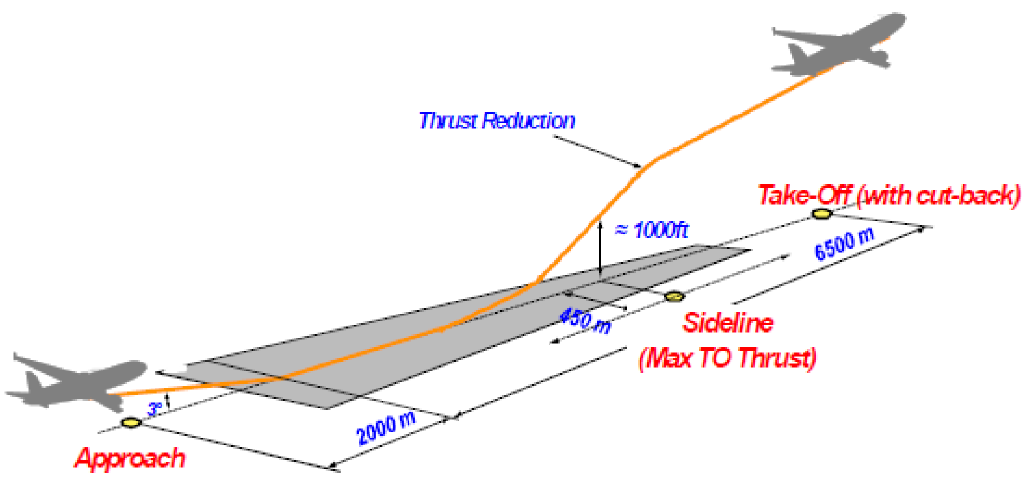

Figure 7, Configuration of measuring points for the certification of aircraft noise emission according ICAO Annex 16 (Source: CFM)

16. MISCELLANEOUS
NOISE ABATEMENT PROC.

16.1 Noise Abatement for ACFT licensed with ICAO Annex 16, Chapter 3:

a) TKOF to 1500FT/GND.
- take-off power
- take-off flaps
- climb at V2+10KT

b) At 1500FT/GND
- reduce power to not less than climb power
- accelaration during climb and retraction of flaps
- normal transition to enroute climb

Figure 8, Excerpt AIP Germany

c) Selected use of runways

The approach of Bremen Airport to use a second runway (RWY 23) for traffic under Visual Flight Rules (VFR) is a practicable solution for separating the VFR- from the Instrument Flight Rules (IFR) traffic. Runway 23 is 700 m long. The use is limited to aircraft up to 5,7 tons maximum take-off mass (MTOM). The noise impact can be reduced due to less populated areas southwest of Bremen Airport compared to the area west of the main runway (see figure 10).

The use of runway 23 is limited for departures that are directed via the points “SIERRA” and “WHISKEY” in the southwest and south of the airport. In order to avoid the need to cross the extended centreline of runway 27 runway 23 is not used for departures to the north.

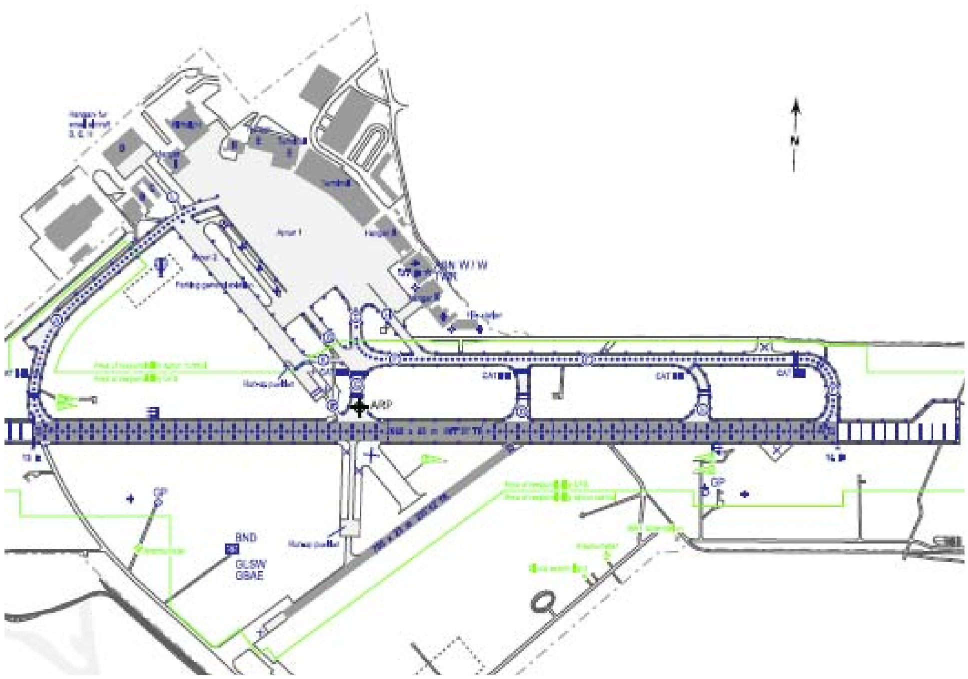

Figure 9, Layout Airport Bremen (AIP), main runway 09/27, secondary runway 23

Figure 10, Overview area southwest of Bremen Airport

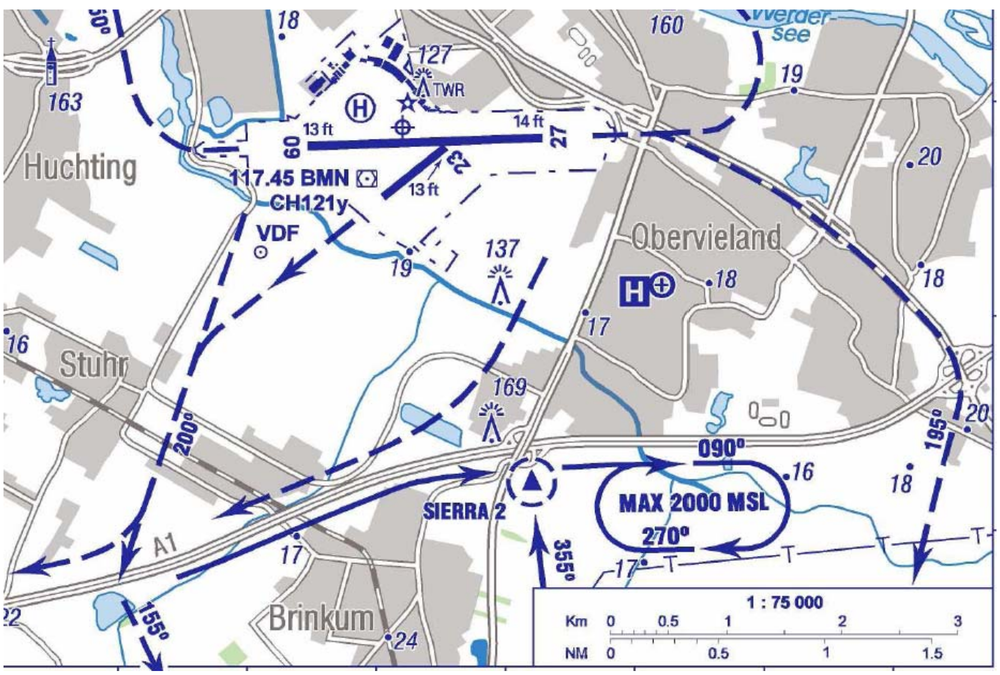

Figure 11, Departure routes Bremen Airport

d) Use of different runway directions

The city of Billund is located south-west of Billund Airport. The approach of Billund Airport to departure to the east and arrive from the east is a feasible procedure at very low traffic times. This will work under certain wind direction and wind velocity conditions. Take offs and landings with a tailwind component have to be agreed by the Pilot in Command (PIC) and is depending on the aircraft performance and runway condition.

e) Intersection take-off

The idea of using intersection M at Billund Airport for take off to avoid additional taxi times and therefore noise and carbon dioxide emissions has to consider following:

Aircraft noise has a square decrease with the altitude of the aircraft. As mentioned before a thrust reduction during take off with an improved climb procedure will overweight the reductions during taxiing. Furthermore is there a safety reason for using the whole runway. In case of an aborted take off (bird strike, technical problems) the remaining runway should be as long as possible. Therefore all airlines and as well pilots do not prefer intersection take offs. Especially in Billunds case where the sensitive areas are located in the south-west of the airport this procedure is not recommended.

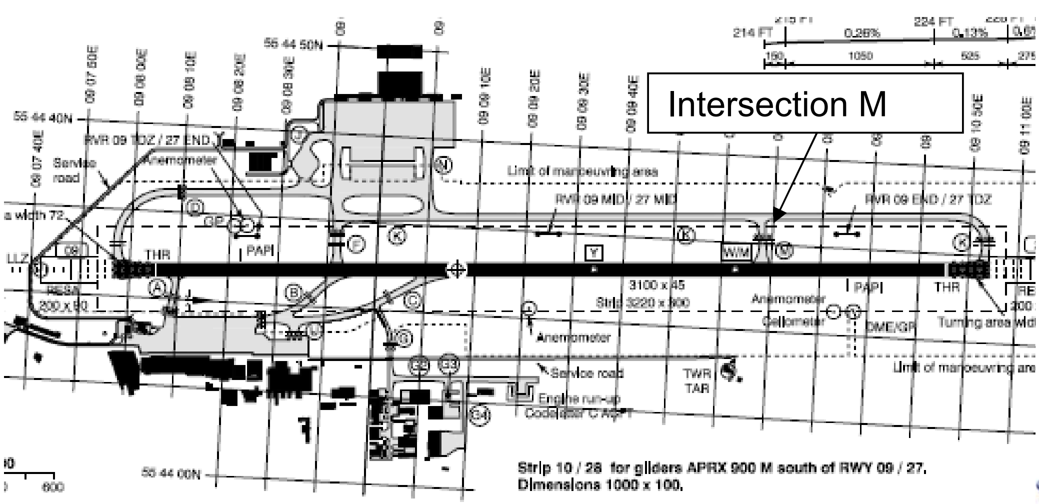

Figure 12, Layout Airport Billund (AIP)

f) Extension of TORA

Noise and fuel reduction and consequential reduction in carbon dioxide emission are achievable with the extension of the length of the runway (take off run available, TORA).

The limit for thrust reductions is given from the aircraft and engine manufacturer and as an example it is limited to 25% for an A 319/320. Boeing aircraft has an additional feature to reduce thrust more than 25% of the maximum available power.

On the other hand longer runways may attract traffic for routes with longer flying distance which require a higher MTOW or the longer runway may be used by larger aircraft. In general heavier and larger aircraft produce more noise than lighter or smaller aircraft. Airports that can serve demand for the use of larger aircraft or aircraft types with higher MTOW after a runway extension will be confronted with higher noise levels. Only under the assumption that the traffic mix (aircraft types, routes) does not change the extension of TORA might reduce noise.

g) Use of taxiways for take-off

According to German air traffic legislation an airport operator might apply to use taxiways as runway for small aircraft. Requirements for the approval by the responsible authority are

- Small aircraft, up to 5,7 tons maximum take-off weight (MTOW)
- Sufficient length and width of the taxiway
- No obstacles.

The effect is not a reduction of noise, but a relocation of noise in preferably less sensitive area.

3.3 Arrival procedures (lateral – vertical profiles / CDAs)

3.3.1 Actual Situation

When arriving and landing aircraft need not to apply as much power as during take-off (the power setting is only 60% of take off thrust), nevertheless, as they follow a 3°-Glidepath (which is relatively flat), in each case causes short time (< 5 min) but high level emissions and annoyances not only in the area beneath the flight track, but also in the areas beside it.

Aircraft Type		MTOW (in t)	Number of Engines	Noise-level according noise certification ICAO-Annex 16 (EPNdB) Calculation: dB(A)=EPNdB - 13		
				T/O	Sideline	Landing
Jet Engine	A 321-100	83	2	86,9	95,5	95,4
	A 320-200	74	2	88,0	94,4	96,2
	B 737-800	79	2	88,6	92,1	96,5
	MD 87	68	2	89,2	97,1	93,3
	A 319-200	64	2	83,8	92,3	92,8
	B 737-500	53	2	83,8	89,9	99,8
	Avro RJ 85	44	4	84,3	88,4	97,3
	Fokker 100	43	2	83,4	89,3	93,1
	Embraer 170	36	2	83,0	94,1	98,1
	Canadair RJ	23	2	78,6	82,2	92,1
Turboprop	Saab 2000	23	2	79,1	86,9	87,9
	ATR 72-200	22	2	86,5	84,7	94,1
	Fokker 50	20	2	86,8	90,5	94,2
	Dash 8-300	19	2	79,8	87	96,3
	ATR 42-300	16	2	82,6	83,8	96,8
	Dash 8-100	16	2	79,8	86,1	97,5

* Quelle: Flight International "Arliners of the world, 1995“
** Quelle: LBA-Lärmlisten 1 und 2 vom 18.01.2005

Figure 13, Aircraft types and noise levels

3.3.2 Possible Solutions

a) Technical improvement airplanes

This approach is very technically and outside of the responsibility of airports. For the purpose of information a small report about a research project in Germany was added to this report:

A very large research project was accomplished and financed under control of the Federal Ministry of Economics in Germany ("Leises Verkehrsflugzeug", engl.: "silent commercial aircraft").

- **Tasks**
  - **Noise optimization for take off and landings**
    - Modelling of Noise sources
    - Forecast Methods for future Noise Contours
    - Potential noise reduction (steep approaches)
    - Measurement campaigns for verifying the forecasts
    - Implementation of the results into NIROS (ATC-Routes)
  - **Low Noise Jet Engines and Noise Location (LEXMOS)**
  - **Active and Passive Noise Reduction on Jet Engines (NASGeT)**
  - **Theoretical Research of Noise Sources**
    - On Aircraft Components
    - Aerodynamical Noise
    - Retrofit possibilities
- **Partners**
  - Deutsche Flugsicherung (German ATC)
  - Deutsche Lufthansa AG
  - Deutsches Zentrum für Luft und Raumfahrt e.V. (DLR)

- EADS Corporate Research Center, Aeronautics, Ottobrunn
- Institut für Flugführung der Technischen Universität Braunschweig
- Ingenieurbüro akustik-data, Berlin
- Flughafen Schwerin-Parchim (EDOP)
- Flughafen München (EDDM)
- Ingenieurbüro SIMULOPT
- Institut für Luft- und Raumfahrt der Technischen Universität Berlin
- Institut für Meteorologie und Klimatologie, Universität Hannover
- Meteorologisches Institut München
- Technisch-Mathematische Studiengesellschaft mbH, Bonn
- Zentrum für Flugsimulation, Berlin

Some results of this project:

Noise optimization for take off and landings:

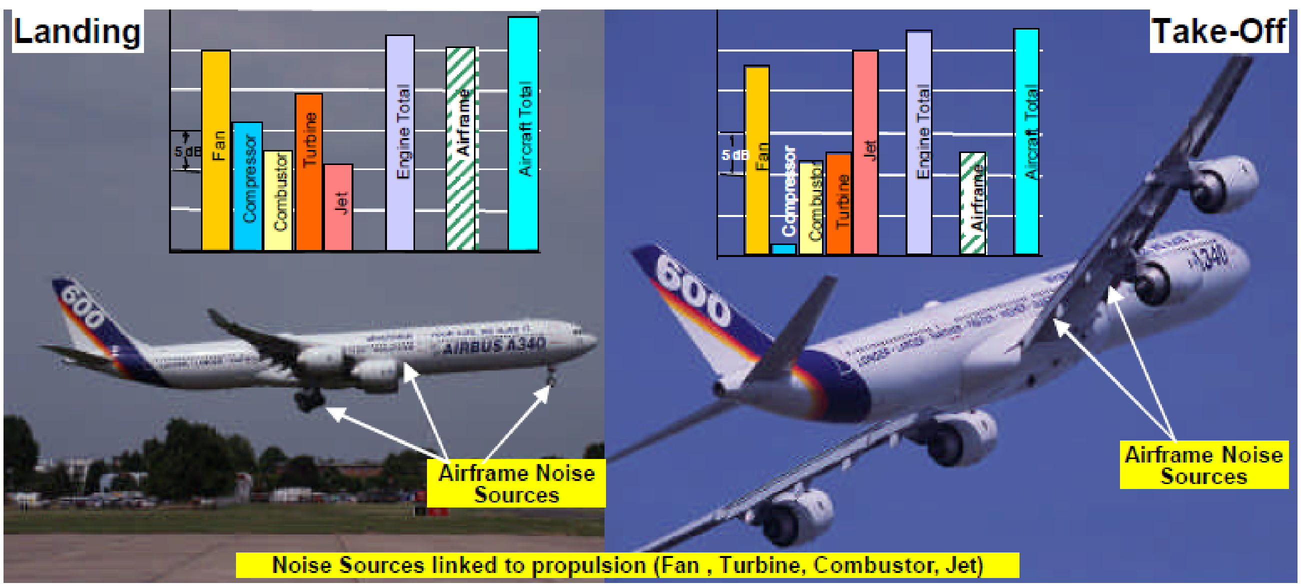

Figure 14, Noise Sources on an Airbus A 34

During landing the airframe structure (especially the high uplift devices like Slats and Flaps) is one of biggest noise sources whilst during take-off it is the engines

(Figure 14). Further investigations were performed on different components of the airframe, e.g. Landing Gear, Engine Intake (part of the airframe), Slats and Flaps.

Figure 15 shows the noise progression on an A 340 wing.

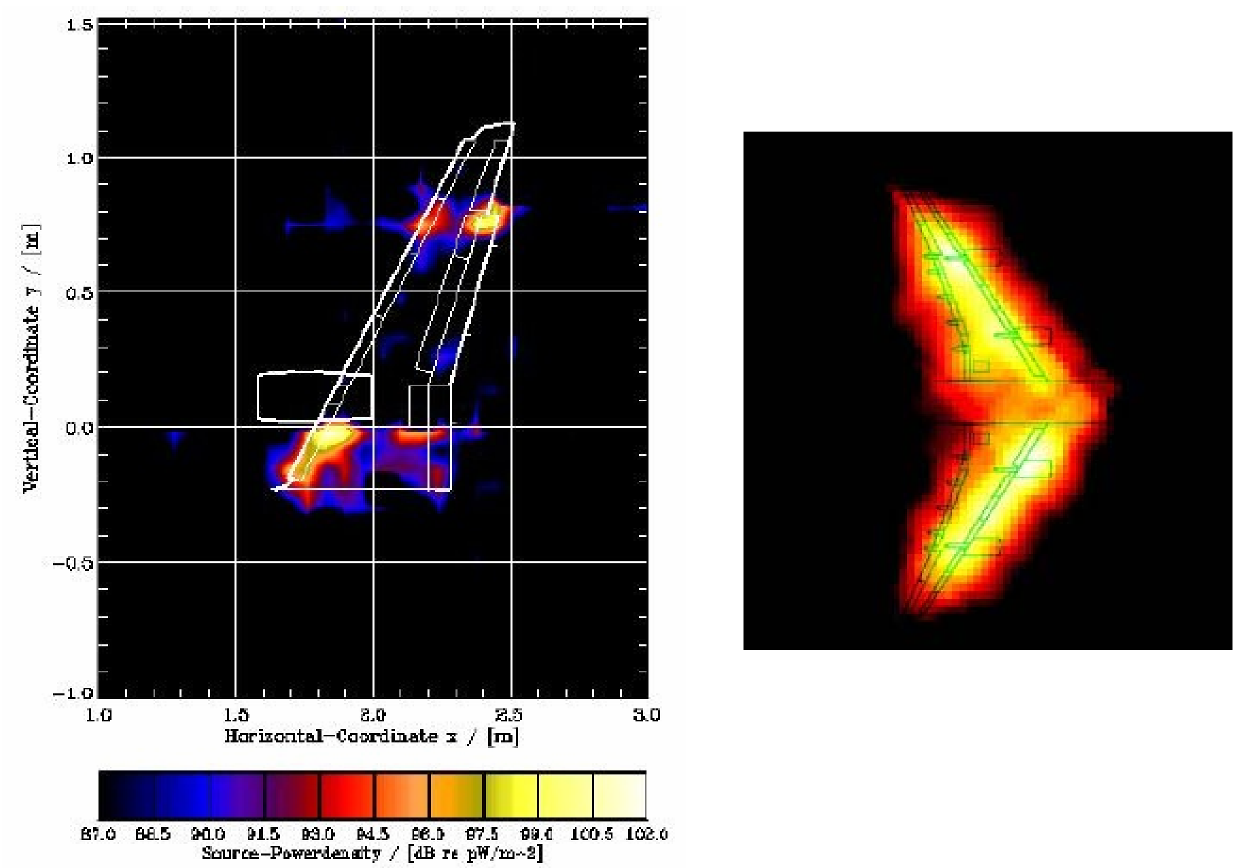

Figure 15, Noise development on an A 340 wing

Figure 15 (left picture) demonstrate the noise source and intensity from a wind tunnel analysis performed on an Airbus wing with a scale 1:10. The noise intensity is dominated by the aero dynamical sources from the high lift devices namely Slats and Flaps. The right picture shows the results of a real A340 wing during an over flight (without Flaps- or Slats setting). The bright areas are showing the highest noise intensity.

Noise optimization for take off and landings (improved climb procedures and steep approach landings):

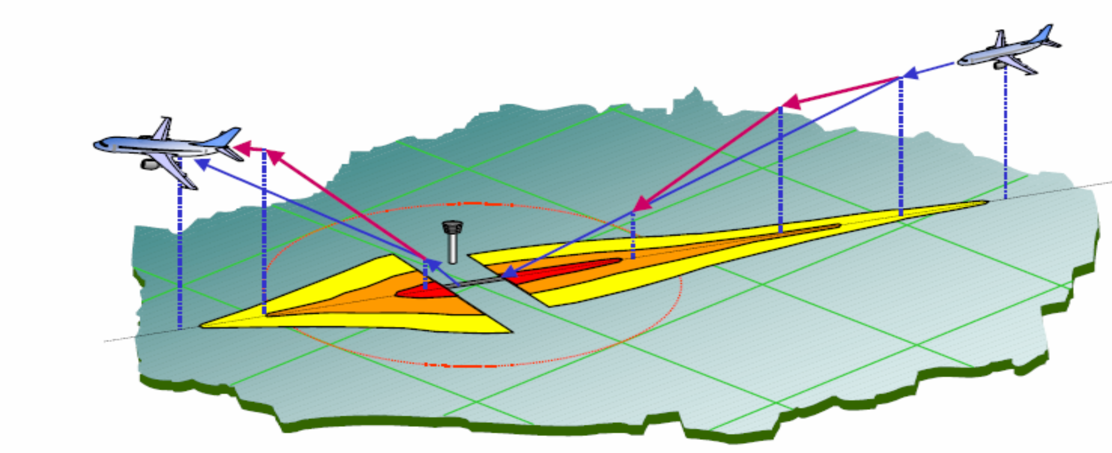

Figure 16, Improved Take Off and Landing Procedures (DLR - Institut für Antriebstechnik, Berlin)

This work package handled the questions about unusual landing and take off procedure e.g. late extension of the landing gears, steep approach angles and Advanced Continuous Descent Approaches (ACDA). ACDA´s allow a continuous descent from the original cruise flight level down to the initial approach fix. Combined with a steep approach this will result in a continuous descent with all engines in idle. Therefore an approach angle of approx. 6° has to be flown. Until today the results of simulations and tests are not very satisfying. The (theoretical) noise reduction is high but the steep approach until touch down seems to be difficult. Today, for most of the aircraft types the approach angle is limited in the certification to 4,5°.

In the case of Continuous Descent Approaches (CDA) engines are running with a power setting of approx. 60% during the last ten nautical miles of the flight (ILS approach). Therefore the noise reduction in the vicinity of airports is limited or not existing.

Active and Passive Noise Reduction on Jet Engines (NASGeT)

Figure 17, Serrated Nozzle Application on a CFM 56 Engine

The reduction of noise emission on jet engines is further on the target for future investigations. Increasing the bypass ratio was one of the most effective solutions during the past years. But this development is now at the physical and economical boundaries. Further investigations are focused on the noise prevention caused by the hot jet blast. The work package NASGeT handled the possibilities of noise reduction under the aspect of retrofit existing engines and future developments of jet engines.

Figure 17 shows a CFM 56 engine installed on an Airbus with a "Serrated Nozzle" to reduce the noise caused from the hot jet blast.

All results of these projects are available under the following address:

www.fv-leiserverkehr.de

Additional possibilities to reduce noise during landing and taxiing to the apron:

a) Taxiing with one engine

As described in the departure section of this report turbo prop aircraft are able to taxi with one engine. For jet engine aircraft it is not recommended because the engine manufacturer's recommendation is to cool down the engines at least 2 minutes with idle power setting. Otherwise the thermal stress can causes damages.

b) Use of thrust reverser

Further each Airport could initiate to publish in the Aeronautical Information Publication (AIP):

"Thrust Reverser should not be used except for safety reasons"

Avoiding the use of thrust reverser is also preferred by the airlines because most of them are using ceramic (carbon) brakes. The behaviour of ceramic material is converse to the former steel brakes. With increasing temperatures of ceramic brakes the wear will decrease and braking effectiveness will increase. In this case the airports and the airlines have the same targets. The objective for the airports is a tremendous noise reduction and the benefit for the airlines is a reduced wear of carbon brakes.

The usage of the thrust reverser is a decision by the pilot and depending on circumstances like Landing Distance Available (LDA), runway conditions etc. Sufficient LDA´s for avoiding the use of thrust reverser are more than 2500m for mid sized aircraft like Boeing 737 and Airbus 319/320. The exact figures are depending on the aircraft size and will increase with higher landing weights.

4 Strategy on Noise abatement (to reduce unnecessary Noise)

Checklist Noise Abatement Measures

The following check-list covers a list of noise abatement measures and an evaluation of the effectiveness for noise reduction. The measures are sorted under consideration of the needed investment.

Investment

Action	Noise Reduction	Carbon Dioxide Reduction	Effectivitiy	
			high	low
Avoidung thrust reverser during landings	x	x	xx	
Intersection take-off	-	-		x
Selection of a not sensitive area for engine tests	x	-	x	
Time restriction for engine test runs	x	-	x	
Selected use of runways	x	-	x	
Use of different runway directions	x	-		x
Use of taxiways for take-off	x	-		x
Thrust reduction procedures	x	x	x	
Night flight restrictions	x	x	x	
Restrictions for training purposes	x	x	x	
Ban of certain aircraft types	x	x	x	
Penalties for delayed flights	-	-		
Additional fees for night or late arrivals	-	-		
Refunds for improved noise abatement procedures	x	-	x	
Taxiing with one engine off	x	x		x
Push back areas for engine start	x	-		x
Advanced Continuous Decent Approaches (ACDA)	x	-		
Use of push back tractor for engine test runs	x	x	x	
Noise protection walls	x			x
Aircraft stands with electrical and pneumatic sources	x	x	xx	
Extension of take-off run available (TORA)	x		x	
Noise protection hangar	x		xxx	
Refunds for noise protection investment (windows, etc)	x		xxx	
Refunds for relocations	x		xxx	

Appendix 1

Power Point Presentation 06th of October 2011

GSA

provincie Drenthe

The Interreg IVB North Sea Region Programme

Investing in the future by working together for a sustainable and competitive region

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