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Measuring the cost-effectiveness of noise-mitigating measures for Schiphol Airport

In the context of the Balanced Approach procedure

2nd addendum to initial report, 22 May 2024 (Final)

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1. Study background

1. Study background

Introduction

On the 24th of June 2022 the Dutch government announced plans to reduce Schiphol's annual capacity from 500,000 to 440,000 movements per year, with the aim to reduce the noise impact around the airport. Such a measure requires a so-called Balanced Approach procedure laid down in EU Regulation 598/2014

The following steps have been taken in the Balanced Approach procedure so far:

1. Define the noise abatement objectives, identify feasible measures to achieve the objectives and assess the cost-effectiveness of each measure and combination of measures
2. Consult relevant stakeholders
3. Determine the most cost-effective combination of measures to achieve the noise objectives by taking the stakeholder inputs into account
4. Notify the European Commission on the preferred combination of measures and discuss their impacts and implementation (ongoing)

1. Study background

Step 1: Define noise objective and assess cost-effectiveness of feasible measures

The first step was conducted between October 2022 and March 2023.

The Ministry of Infrastructure and Water Management set a noise objective which should be reached by November 2024:

Noise objectives with respect to baseline	
• Houses within 58 dB(A) Lden contour	-20%
• Highly annoyed people within 48 dB(A) Lden contour	-20%
• Houses within 48 dB(A) Lnight contour	-15%
• Severely sleep disturbed people within 40 dB(A) Lnight contour	-15%

The Ministry commissioned a consortium consisting of Decisio, Beelining and To70 to short-list feasible measures and assess their cost-effectiveness.

The results of this analysis can be found here: [Decisio and Beelining \(2023\). Cost-effectiveness of noise mitigating measures for Schiphol. Final Report. 10 March 2023](#)

1. Study background

Step 2: Consult relevant stakeholders

Stakeholders were consulted on the Balanced Approach procedure and the cost-effectiveness study between March 15 and June 15 2023 (as prescribed by EU Regulation 598/2014).

The consultation phase yielded 224 responses from local governments, local communities, environmental organization, airlines and the airport.

Based on the inputs several measures were removed from the short-list (for safety and feasibility reasons), whereas others were added:

Removed:

- Stimulate airlines to use quieter aircraft, as this cannot be implemented before nov. 2024
- Extend the night regime, as this would increase peaks and complexity in the shoulder-periods
- Runway closure (Buitenveldertbaan), as the use of this runway is already minimized

Added:

- + Additional fleet renewal
- + Use of quieter aircraft during nighttime period

1. Study background

Several other promising measures were suggested during the consultation phase, such as a ban on noisy aircraft, stronger differentiation of airport charges and a night curfew.

These measures either needed further analysis or could not be implemented before November 2024. As they could not contribute to the noise objective set for november 2024, they were therefore excluded from further analysis.

It appeared that the limited set of measures that remained would require a significant reduction in the number of flight movements. This was not considered sensible by the Ministry.

To allow room for other promising measures that require more time to implement, the Ministry decided to achieve the noise objectives using a stepped approach.

The majority of the objectives - approximately a 15% reduction in affected houses, highly annoyed and sleep disturbed people – should still be reached by November 2024. The remaining 5% in the 24-hour period should be realized thereafter.

1. Study background

Step 3: Determine most cost-effective combination of measures to achieve the noise objective

Two sets of measure combinations were defined that are able to achieve the updated noise objectives for November 2024:

Combination A	Combination B
Use of quieter aircraft during nighttime period	Use of quieter aircraft during nighttime period
Minimize the use of secondary runways	Minimize the use of secondary runways
Cap on total annual flight movements: 452,500	Cap on total annual flight movements: 462,500
Cap on annual flight movements during the night: 28,700	Cap on annual flight movements during the night: 27,000

The cost-effectiveness of each measure and combinations of measures was assessed by Decisio, Beelining and To70. The results of the analysis are described in an addendum to the initial report: [Decisio and Beelining \(2023\). Measuring the cost-effectiveness of noise mitigating measures for Schiphol. Addendum to initial report. 31 August 2023](#)

Combination A was preferred by the Ministry. Combination B appeared more restrictive than necessary – with respect to the noise objectives for the night – which is not allowed by the Environmental Noise Directive.

1. Study background

Step 4: Notify the European Commission on the preferred combination and discuss impact and implementation

The preferred combination was notified to the European Commission on 1 September 2023. Since then the Ministry and the Commission have been actively discussing the measures and their implementation.

As the notification process takes more time than anticipated and to meet the concerns raised by the European Commission about the proportionality of the measures, implementation of the notified measures by November 2024 no longer seems plausible. Therefore the Ministry decided to delay the implementation until the winter season (November 2025).

While disappointing for local communities, the delay provides an opportunity to come up with a proposal for a more gradual implementation of measures. This means that the measures will be assessed and implemented more spread in time..

The Ministry commissioned Decisio, Beelining and To70 to update the previous study and to include promising measures that become feasible due to the delayed implementation.

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2. Cost-effectiveness of individual measures

Approach

The following changes were made compared to the previous study:

1. Update of the study baseline and assumptions

The gradual implementation requires an update of the baseline. The new baseline now represents traffic in 2025 instead of 2024. It has been assumed that fleet renewal follows the long-term trend.

Furthermore, the price level has been changed to reflect 2023 (was 2022).

2. Changes to existing measures

- Minimize the use of secondary runways: limited to one period during the day 13:00-15:00h (doubts were raised about feasibility in the morning period 07:00-08:00h)

3. Included new measures

Measures that become feasible due to the delayed implementation include:

- Stronger differentiation of airport charges*
- Ban on noisy aircraft
- Additional fleet renewal

* A similar measure was assessed in the [initial study](#), but [later rejected](#) as it could not be implemented by nov. 2024. Due to the delay in the process, this measure now becomes feasible.

Minimize the use of secondary runways

The runways at Schiphol are characterized as primary or secondary based on the level of noise they cause. The runways are used according to noise preferential tables (at the right). Increasing the use of the noise preferential runways could reduce the noise impact of the airport

This measure falls under Pillar 3 of the Balanced Approach (noise abatement operational procedure)

Current situation

The Kaag-runway (06-24) and Polder-runway (36L-18R) are the noise preferential runways during the day and night (under normal weather conditions) and are also used most intensively

Preferential runway combinations

	Landings		Starts		
	L1	L2	S1	S2	
Day (06:00-23:00)	1	06 (36R)	36L	(36C)	
	2	18R (18C)	24	(18L)	
	3	06 (36R)	09	(36L)	
	4	27 (18R)	24	(18L)	
	5a	36R (36C)	36L	(36C)	
	5b	18R (18C)	18L	(18C)	
	6a	36R (36C)	36L	(09)	
	6b	18R (18C)	18L	(24)	
	Night	1	06	36L	
		2	18R	24	
3		36C	36L		
4		18R	18C		

Minimize the use of secondary runways

Measure

Increasing the threshold for using the secondary runways forces more flights to the noise preferential runways

Assumptions

Contrary to the [initial study](#) it is now assumed that the measure is only implemented during the afternoon between 13:00-15:00h. The approach during the afternoon period is similar to that in the initial study.

Forcing 1+1 runway use in the morning peak period 07:00 – 08:00h seems to be, after consultation with stakeholders, infeasible at Schiphol. Therefore, the morning period is not included in the measure anymore

Minimize use of secondary runways

Cost estimation

- **Passengers:**
 - Change in generalised travel costs: travel time change x time valuation for air passengers in Netherlands
- **Airlines:**
 - Change in operational costs: flight/taxi time change x operational costs per block hour per business segment
 - Airlines will fully absorb increase in operational costs because of competitive market
- **Airports:**
 - No impact as total number of flight movements does not change.
- **Indirect economic impacts (agglomeration effects)**
 - Negative impact on business climate around Schiphol due to less attractive network and higher travel costs may lead to lower overall productivity.
- **Government:**
 - No impact as total number of flight movements does not change.
- **Society:**
 - No impact as total number of flight movements does not change.
- **Employment and value added**
 - No gross impact as the total number of flight movements does not change

Results: Minimize the use of secondary runways

Total costs:

- Passengers are confronted with higher travel time costs due to longer flight and taxi-times
- Airlines are confronted with higher operational costs due to longer flight and taxi-times
- Total yearly flights at 500k are the same as in the baseline, therefore no effect on employment and net external impacts

Cost effectiveness of reduction per house/annoyed person:

- Measure is relatively cost-effective
- Measure has limited potential to reduce noise. Also the noise reduction is limited to the daytime.
- Costs and noise impacts are smaller compared to those in the [initial study](#), because of the shorter timeframe in which the measure is applied

Minimize use of 2nd runways	
<i>Net costs</i>	
Operational costs airlines	-€ 1,8
Generalised travel cost passengers/freight	-€ 1,7
Government costs	
Direct costs	-€ 3,5
Net External effects (less flights)	
Climate effects - CO2 and non CO2	
Air quality - NoX	
Air quality - PM10	
Additional economic impact Schiphol (agglomeration)	-€ 0,5
Total costs (including indirect and external costs):	-€ 4,0

With respect to baseline 500k:	Change in number of houses/persons:	Change in % of houses/persons:	<i>Net operational costs per reduction of:</i>	<i>Direct costs per reduction of:</i>	<i>Total costs per reduction of:</i>
houses in 58 dB Lden Contour	-80	-1,2%	-€ 22.000	-€ 43.648	-€ 50.195
houses in 48 dB Lnight Contour	-				
highly annoyed persons in 48 Lden Contour	-1.822	-1,7%	-€ 966	-€ 1.916	-€ 2.204
highly annoyed persons in 40 Lnight Contour	-				

= Noise abatement objective not achieved
 = Noise abatement objective achieved

Stronger differentiation of airport charges

The measure aims to reduce the noise impact by stimulating airlines to replace noisy aircraft types by quieter types through a stronger differentiation of airport charges

This measure falls under Pillar 1 of the Balanced Approach (reduce aircraft noise at source)

Current situation

- Airport charges at Schiphol are already differentiated based on the noise production of the aircraft
- Schiphol distinguishes 7 categories of aircraft ranging from S1 (most noisy in their class) to S7 (least noisy)
- The table shows how the landing charges differ based on the noise category (for connected handling during the daytime). For the nighttime, the differentiations are larger

Category	Noise level	Landing charge
S1	▲ EPNdB > -11	200%
S2	-11 >= ▲ EPNdB < -15	145%
S3	-15 >= ▲ EPNdB < -18	100%
S4	-18 >= ▲ EPNdB < -21	80%
S5	-21 >= ▲ EPNdB < -24	65%
S6	-24 >= ▲ EPNdB < -27	50%
S7	▲ EPNdB <= -27	40%

Note: Landing charges are levied per MTOW

- During the daytime category S3 connected aircraft for instance pay the base fee per MTOW. S1 aircraft pay twice that amount per MTOW, S6 aircraft pay half

Stronger differentiation of airport charges



Aircraft types by noise category

Geluidscategorie S1	Geluidscategorie S2	Geluidscategorie S3	Geluidscategorie S4	Geluidscategorie S5	Geluidscategorie S6	Geluidscategorie S7
Airbus A300 Airbus A320 Airbus A321	Airbus A310 Airbus A319 Airbus A330	Airbus A318		Airbus A330-900 Airbus A340	Airbus A220 Airbus A321NEO Airbus A350 Airbus A380	Airbus A320NEO
B727 B737 – niet vermelde typen B747-200 B767-100/200/300	B737-600/700/900 B747-400 B757 B767-400 B777		B717		B737-800MAX B747-800 B787	
Antonov niet vermelde typen BAe niet vermelde typen DC-8/9/10 Embraer E75L Fokker 27/50 Ilyushin alle typen Lockheed alle typen MD-81/82/83/87/88 Tupolev alle typen Yak42	Antonov 148 ATR42 ATR72 Canadair CL601/604 Embraer 170/175/190/195 Fokker 100 MD-11 Sukhoi Superjet SU9 Shorts 360	BAe 146/AVRO RJ series Bombardier CRJ700 Bombardier 900 Canadair CL600 Canadair RJ 700/900	BAe 125-800 Fokker 70 MD-90	BCS3 Canadair RJ100/200 DHC (DH8D) Embraer E120/135/145		Embraer 195-200
Beech alle typen Cessna 650 Falcon 10/20/50 Gulfstream II/III Hawker 700		Bombardier Global Express Cessna 500/560 XL/750 Falcon 200/900/2000/7x Gulfstream IV/V or 650 Hawker 750/800/800 XP IAI Galaxy IAI niet vermelde typen Learjet 31/35/36/45/55/60SPX		Dornier 328/jet Saab alle typen		
Alle vliegtuigen niet vermeld in geluidscategorieën S1, S2, S3, S4, S5, S6 of S7	Alle helikopters		Alle vliegtuigen < 6 ton MTOW Alle propellervliegtuigen ≤ 9 ton MTOW			

Source: Schiphol Charges and Conditions 2024: <https://www.schiphol.nl/en/download/b2b/1698740622/1Ug8LB2ayP2peAQqF4ut63.pdf>

Stronger differentiation of airport charges

The EU Directive 2009/12/EC on airport charges states that airport charges should be cost-based. Therefore a charge increase for a specific noise category should be accompanied by a decrease in another category or categories to ensure that total revenues do not exceed costs.

Measure

- S1: Charge increase. According to Schiphol 859* flight movements fell in the S1 category in 2022. This includes mainly Airbus A300-600 and Boeing 737-300 aircraft.
- S2 – S7: Charge decrease (by the same absolute amount as charges for category S1 increase)

Airlines can either choose to keep operating their S1 aircraft at Schiphol (and pay a higher charge), replace the S1 aircraft with quieter types or abolish the flights altogether. In the short-term (at least until 2025) replacement will only be possible when airlines already have quieter types available in their fleet.

The extent to which airlines can shift aircraft in the short-term depends on:

- Ability to shift: *Are they based on Schiphol or not?*
- Fleet composition: *Do they have sufficient quieter aircraft available in their fleets?*
- Market conditions: *Does it make economic/operational sense to shift aircraft?*

* Variants of a specific aircraft type may belong to different aircraft categories. This had not been taken into account in the [initial study](#) which led to a too high estimate of S1 movements.

Stronger differentiation of airport charges

Assumptions

Given the difficulty in predicting how each airline responds to a change in airport charges and because only a limited number of flights is affected, the following simplifying assumptions were made:

- Passenger flights operated with S1 aircraft are either replaced or abolished (and moved to other airports);
- Cargo flights operated with S1 aircraft are abolished (and moved to other airports) due to the inability of most cargo operators to replace S1 flights with quieter types.

Forcing all affected airlines to replace or abolish their S1 flights at Schiphol requires a fairly large increase in the airport charges for the respective flights.

The costs of replacing or abolishing the flights are assumed to be half of the costs associated to keep operating the S1 aircraft at Schiphol and paying the higher charge.

It should be noted that this approach provides an upper bound for the associated impacts. As it is assumed (following the assumptions of the noise modelling regarding this measure) that the airport charge is high enough to either replace or abolish all flights with S1 aircraft at Schiphol .

Stronger differentiation of airport charges

Cost estimation

- **Passengers/Freight:**
 - Cargo carriers with S1 aircraft move to other airports, this means an increase in the generalised travel cost for freight.
- **Airlines:**
 - Cost of reallocation of aircraft across fleet → less efficient operation. Cost of reallocation from S1 type aircraft to S2-S7 is estimated by the increase of the airport charges for S1 aircraft using the rule-of-half (we do not exactly know when airlines will reallocate to quieter aircraft).
- **Airports:**
 - No overall impact on profitability. Less aeronautical revenues due to more efficient fleet, but this will be compensated in the charges, as charges need to remain cost-based.
- **Indirect economic impacts (agglomeration effects)**
 - Negative impact on business climate around Schiphol due to less attractive network and higher travel costs may lead to lower overall productivity.
- **Government:**
 - In short-term unemployment allowances increases and tax revenue decreases.
- **Society:**
 - No overall impact on CO2 and non-CO2 as noisy (and probably less-efficient aircraft) are deployed elsewhere
- **Employment and value added:**
 - S1 cargo flights are replaced by passenger flights. Passenger flights are less labour-intensive than cargo flights. This means an increase in (short-term) frictional unemployment. In the long-term the labour market is competitive as stated in the CBA guidelines of the Central Planning Bureau.

Results: Stronger differentiation of airport charges

Total costs:

- Airlines are confronted with higher operational costs associated with the replacement and/or abolishment of S1 aircraft
- Shippers are confronted with an increase in travel costs due the fact that cargo flights move to other airports
- The government may encounter a short-term increase in unemployment allowances and a decrease in tax revenues due to less employment at Schiphol when cargo flights are replaced by passenger flights.

Cost effectiveness of reduction per house/annoyed person:

- Measure is not cost-effective
- Measure has very limited potential to reduce noise.

Stronger differentiation of airport charges	
<i>Net costs</i>	
Operational costs airlines	-€ 4,4
Generalised travel cost passengers/freight	-€ 4,0
Government costs	-€ 0,7
Direct costs	-€ 9,0
<i>Net External effects (less flights)</i>	
Climate effects - CO2 and non CO2	
Air quality - NoX	
Air quality - PM10	
Additional economic impact Schiphol (agglomeration)	-€ 1,3
Total costs (including indirect and external costs):	-€ 10,3

With respect to baseline 500k:	Change in number of houses/persons:	Change in % of houses/persons:	<i>Net operational costs per reduction of:</i>	<i>Direct costs per reduction of:</i>	<i>Total costs per reduction of:</i>
Houses in 58 dB Lden Contour	-9	-0,1%	-€ 488.294	-€ 1.005.088	-€ 1.144.595
Houses in 48 dB Lnight Contour	-52	-1,0%	-€ 84.512	-€ 173.958	-€ 198.103
Highly annoyed persons in 48 Lden Contour	-194	-0,2%	-€ 22.653	-€ 46.628	-€ 53.100
Highly annoyed persons in 40 Lnight Contour	-143	-0,6%	-€ 30.732	-€ 63.257	-€ 72.037
		= Noise abatement objective not achieved			
		= Noise abatement objective achieved			

Ban on noisy aircraft

The measure aims to reduce the noise impact by banning relatively noisy aircraft from Schiphol

This measure falls under Pillar 4 of the Balanced Approach (Operating restrictions)

Current situation

- Only aircraft with a cumulative margin of at least -10 EPNdB are allowed at Schiphol

Measure

- Nighttime ban on aircraft with cumulative margin lower than -13 EPNdB: around 2,612 flight movements

Airlines can either choose to replace the respective flights with quieter types or abolish the flights (and move them to other airports). The approach is similar to the approach used for assessing the impacts of a stronger differentiation of airport charges

Ban on noisy aircraft

Cost estimation

- **Passengers/Freight:**
 - Cargo carriers with noisy aircraft move to other airports, this means an increase in the generalised travel cost for freight.
- **Airlines:**
 - Increased operational costs in the short-term as higher fixed costs (depreciation, insurance and rentals) outweigh lower variable costs (fuel and maintenance) in the short-term. Over the longer-term – outside the scope of this assessment – the lower variable costs will outweigh the higher fixed costs.
 - Airlines will fully absorb increase in operational costs because of competitive market.
- **Airports:**
 - No overall impact on profitability. Less aeronautical revenues due to more efficient fleet, but this will be compensated in the charges, as charges need to remain cost-based.
- **Indirect economic impacts (agglomeration effects)**
 - Negative impact on business climate around Schiphol due to less attractive network and higher travel costs may lead to lower overall productivity.
- **Government:**
 - In short-term unemployment allowances increases and tax revenue decreases.
- **Society:**
 - No global impact on CO₂ and non-CO₂ as older aircraft are deployed elsewhere.
 - Mixed impact on local air quality. Negative impact on NO_x and PM as newer aircraft emit more NO_x and PM than older aircraft. Positive impact on CO and HC as newer aircraft emit less of these substances than older aircraft.
- **Employment and value added (local effect):**
 - Banned noisy cargo flights are replaced by passenger flights. Passenger flights are less labour-intensive than cargo flights. This means an increase in (short-term) frictional unemployment. In the long-term the labour market is competitive as stated in the CBA guidelines of the Central Planning Bureau

Results: Ban on noisy aircraft

Total costs:

- Airlines are confronted with higher operational costs associated with replacing banned aircraft with other types
- Shippers are confronted with an increase in travel costs due the fact that cargo flights move to other airports
- The government may encounter a short-term increase in unemployment allowances and a decrease in tax revenues due to less employment at Schiphol because cargo flights are replaced by passenger flights.

Cost effectiveness of reduction per house/annoyed person:

- Measure is less cost-effective than the reduced use of secondary runways, but more effective than stronger differentiation of airport charges
- Measure has potential to reduce noise during the night.

Ban on noisy aircraft	
<i>Net costs</i>	
Operational costs airlines	-€ 12,4
Generalised travel cost passengers/freight	-€ 8,2
Government costs	-€ 1,2
Direct costs	-€ 21,8
<i>Net External effects (less flights)</i>	
Climate effects - CO2 and non CO2	
Air quality - NoX	
Air quality - PM10	
Additional economic impact Schiphol (agglomeration)	-€ 3,1
Total costs (including indirect and external costs):	-€ 24,9

With respect to baseline 500k:	Change in number of houses/persons:	Change in % of houses/persons:	<i>Net operational costs per reduction of:</i>	<i>Direct costs per reduction of:</i>	<i>Total costs per reduction of:</i>
Houses in 58 dB Lden Contour	-86	-1,3%	-€ 144.383	-€ 254.345	-€ 290.333
Houses in 48 dB Lnight Contour	-300	-5,6%	-€ 41.177	-€ 72.537	-€ 82.801
Highly annoyed persons in 48 Lden Contour	-1.276	-1,2%	-€ 9.688	-€ 17.066	-€ 19.481
Highly annoyed persons in 40 Lnight Contour	-505	-2,2%	-€ 24.465	-€ 43.098	-€ 49.196
		= Noise abatement objective not achieved			
		= Noise abatement objective achieved			

Additional fleet renewal

Fleet renewal is a continuous process driven by operational costs. A trend-based development of airline fleets is therefore assumed in the baseline scenario. As the noise objectives are defined against the baseline, the objectives also implicitly assume a trend-based development of airline fleets.

During the consultation phase and notification phase it became clear that certain airlines at Schiphol renew their fleets at a faster pace than the assumed trend-based development between November 2024 and November 2025. The contribution of this accelerated fleet renewal – the level of fleet renewal above and beyond the trend-based development - to the noise objectives shall be estimated. It should be noted however that the pace of fleet renewal may decline after 2025 (and, over the longer term, returning back to the trend-based development).

Fleet renewal decisions have been made prior to the government's announcement to reduce Schiphol's capacity. This means that any fleet renewal until 2025 is the result of airline business decisions made in the past. Fleet renewals therefore should not be confused with *measures* to reduce noise at Schiphol. As fleet renewals cannot be considered as measures, no additional costs apply.

We do not calculate any additional costs or cost-effectiveness for fleet renewal, as investment decisions for fleet renewal have been made years ago. As fleet renewal for certain airlines seems to be above the long-term development included in the baseline it contributes to some extent to the noise objectives in reducing houses and annoyed persons. For the results in noise reduction we refer to the the Balanced approach noise study conducted by to70 (May 2024).

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3. Overview results measures

Overview results measures

In the table below the total costs (in 2025) of the individual measures are compared:

Total costs in million euro's with respect to baseline (500k)

	Minimize use of 2nd runways	Stronger differentiation of airport charges	Ban on noisy aircraft	Additional fleet renewal*
<i>Net costs</i>				
Operational costs airlines	-€ 1,8	-€ 4,4	-€ 12,4	-
Generalised travel cost passengers/freight	-€ 1,7	-€ 4,0	-€ 8,2	-
Government costs	-	-€ 0,7	-€ 1,2	-
Direct costs	-€ 3,5	-€ 9,0	-€ 21,8	-
Net External effects (less flights)				
Climate effects - CO2 and non CO2				
Air quality - NoX				
Air quality - PM10				
Additional economic impact Schiphol (agglomeration)	-€ 0,5	-€ 1,3	-€ 3,1	-
Total costs (including indirect and external costs):	-€ 4,0	-€ 10,3	-€ 24,9	-

* Investment decisions and associated costs of fleet renewal for 2025 are also incurred in the baseline (years ago). Therefore, we see no changes in costs in 2025.

Overview results measures

In the table below the cost-effectiveness (in 2025) of the individual measures are compared:

Costs in euro's per house/annoyed persons with respect to baseline (500k)

With respect to baseline 500k:	Minimize use of 2nd runways	Stronger differentiation of airport charges	Ban on noisy aircraft	Accelerated fleet renewal
<i>Change in number of houses/persons:</i>				
Houses in 58 dB Lden Contour	-1,2%	-0,1%	-1,3%	X
Houses in 48 dB Lnight Contour	0,0%	-1,0%	-5,6%	X
Highly annoyed persons in 48 Lden Contour	-1,7%	-0,2%	-1,2%	X
Highly annoyed persons in 40 Lnight Contour	0,0%	-0,6%	-2,2%	X
Net operational costs per reduction of (wrt baseline 500k):				
Houses in 58 dB Lden Contour	-€ 22.000	-€ 488.294	-€ 144.383	
Houses in 48 dB Lnight Contour		-€ 84.512	-€ 41.177	
Highly annoyed persons in 48 Lden Contour	-€ 966	-€ 22.653	-€ 9.688	
Highly annoyed persons in 40 Lnight Contour		-€ 30.732	-€ 24.465	
Direct Costs per reduction of (wrt baseline 500k):				
Houses in 58 dB Lden Contour	-€ 43.648	-€ 1.005.088	-€ 254.345	
Houses in 48 dB Lnight Contour		-€ 173.958	-€ 72.537	
Highly annoyed persons in 48 Lden Contour	-€ 1.916	-€ 46.628	-€ 17.066	
Highly annoyed persons in 40 Lnight Contour		-€ 63.257	-€ 43.098	
Total costs per reduction of (wrt baseline 500k) :				
Houses in 58 dB Lden Contour	-€ 50.195	-€ 1.144.595	-€ 290.333	
Houses in 48 dB Lnight Contour		-€ 198.103	-€ 82.801	
Highly annoyed persons in 48 Lden Contour	-€ 2.204	-€ 53.100	-€ 19.481	
Highly annoyed persons in 40 Lnight Contour		-€ 72.037	-€ 49.196	

= Noise abatement objective not achieved

= Noise abatement objective achieved

Overview results measures

- Minimizing use of secondary runways is most cost-effective of the three measures analysed. However, it contributes relatively little to the noise objective during the entire day and has no impact on noise during the night.
- The [previous study](#) showed that only one measure is more cost-effective: operating quieter aircraft during the night. It contributes relatively much to the noise objectives for the night, but less to the objectives during the entire day.
- Stronger differentiation of airport charges is not cost-effective and hardly contributes to the noise objective.
- A ban on noisy flights leads to significant cost increases for airlines, and – to a limited extent - contributes to the noise objective, especially during the night.
- No additional costs are associated with accelerated fleet renewal as investment decisions have been made years ago. However, because certain airlines renew their fleet at a faster pace than the assumed trend-based development in the baseline it does contribute marginally to the noise objective.
- None of the measures are able to reach the noise objectives on their own. Therefore, a combination of measures is required.