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

In the context of the Balanced Approach procedure

Final report, 10-3-2023

Sibren Vegter, Niels Hoefsloot (Decisio) and Rogier Lieshout (Beelining)

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1. Study background

1. Study background

On the 24th of June 2022 the Dutch cabinet 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. The capacity reduction should be implemented as of November 2024

When a noise problem is identified at an EU airport with more than 50,000 annual movements, the so-called Balanced Approach procedure has to be followed. The Balanced Approach procedure is laid down in EU Regulation 598/2014

The Balanced Approach concept was developed by ICAO and adopted by its Assembly in 2001. It has been reaffirmed in all subsequent Assembly sessions

1. Study background

The Balanced Approach procedure in the EU consists of the following steps:

1. Define the noise abatement objective for the airport at hand
2. Identify possible measures that may (partly) contribute to the noise objective. The Balanced Approach distinguishes four pillars of measures:
    - Reduce aircraft noise at source
    - Land-use planning and management
    - Noise abatement operational procedures
    - Operating restrictions (only to be implemented when aforementioned measures have been considered and found to be insufficient or less cost-effective)
3. Evaluate the cost-effectiveness of each measure and combinations of measures
4. Consult with stakeholders
5. Adopt and implement the (combination of) measure(s) that reach the noise objective in the most cost-effective way

1. Study background

The Ministry of Infrastructure and Water Management has defined the noise abatement objective (step 1)

Noise abatement objectives with respect to baseline (nov 2024)	
• Houses in 58 dB Lden contour	-20%
• Highly annoyed persons in 48 Lden contour	-20%
• Houses in 48 dB Lnight contour	-15%
• Highly annoyed persons in 40 Lnight contour	-15%

The Ministry commissioned a consortium consisting of Decisio, Beelining and To70 to:

- Identify possible noise mitigating measures and combinations of measures (step 2) and
- Evaluate their cost-effectiveness (step 3)

For the selection of the (combinations of) measures we refer to the report of To70. This report focuses on the cost-effectiveness of the (combinations of) measures

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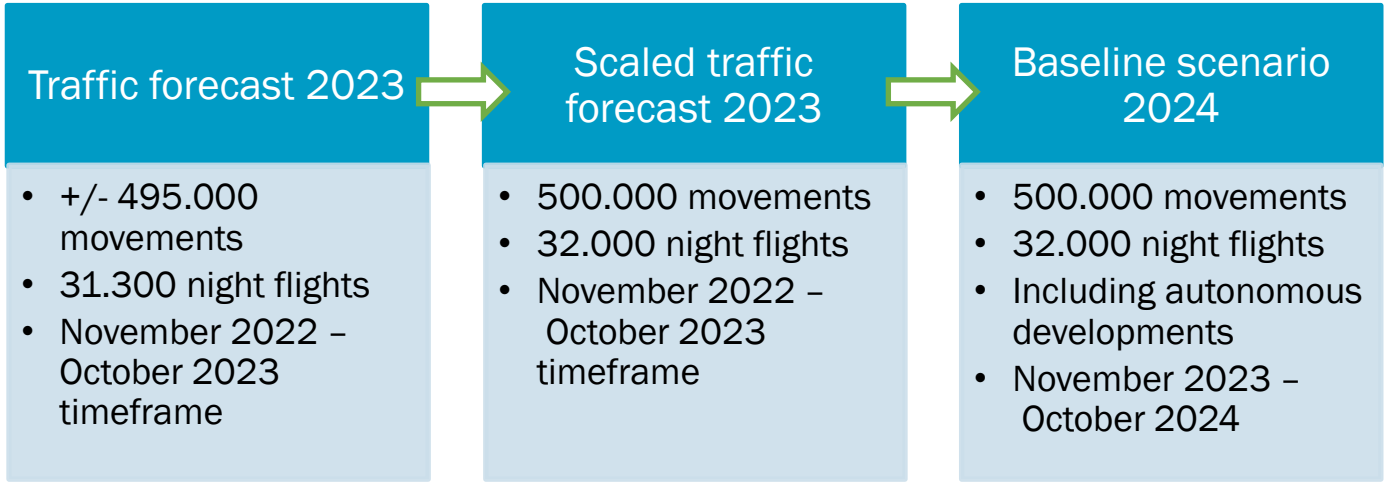
2. Definition of cost-effectiveness

2. Definition of cost-effectiveness

Baseline scenario

The cost-effectiveness of each measure is estimated for november 2024 with respect to the baseline; the year for which the noise abatement objectives are defined. Therefore, we first developed a new baseline scenario for 2024 based on the latest traffic forecast for Schiphol (for operational year* 2023) and taking into account autonomous developments (which is a specific requirement in EU Regulation 598/2014). For a more extensive explanation of the baseline we refer to the to70 report.



Autonomous developments taken into account until 2024:

- Autonomous fleet renewal
- Increased runway capacity for arrivals
- Increased use of CDA procedures
- Increased use of reduced flaps arrival procedures

* The operational year ('Gebruiksjaar" in Dutch) runs from November 2022 to October 2023. The Ministry would like to end the so-called anticipatory enforcement regime ('anticiperend handhaven' in Dutch) by november 2023 and return to the regime with noise enforcement points in combination with strict preferential runway use. This might reduce capacity as of november 2023. As it is currently unclear whether this will occur, it has not been taken into account in the baseline scenario

2. Definition of cost-effectiveness

What costs to include?

EU Regulation 598/2014 prescribes a comparison of the costs of the measures. A full Cost-Benefit Analysis (CBA) is not required although Member States may conduct a CBA when deemed appropriate

The Regulation does not provide a definition of cost-effectiveness nor does it specify which costs should be taken into account. However, it does mention that operating restrictions should be assessed by taking into account:

- The anticipated noise benefit, now and in the future
- The safety of operations
- The capacity of the airport
- Impacts of the European aviation network and an assessment of cross-border impacts

In addition, competent authorities may take other impacts into account, such as: health and safety of local residents, environmental impacts and direct, indirect, catalytic economic impacts

2. Definition of cost-effectiveness

Previous cases

Few cases are known in which the Balanced Approach procedure was followed:

- France (studies on a reduction of the number of night flights at specific airports):
  - Noise impacts: reduction in number of houses and persons within specific contours or reduction in noise level
  - Costs: changes in gross employment and value added
  - Cost-effectiveness: not specified

2. Definition of cost-effectiveness

Our definition

To align with the noise objective we define the noise impacts in terms of the change in number of:

- Houses within the 58 dB Lden and 48 dB Lnight contours
- Highly annoyed persons within the 48 dB Lden and severely sleep disturbed within the 40 dB Lnight contours

We use broad definition of costs which aligns with the approach used in Cost-Benefit Analyses (CBA) in particular the guideline on aviation specific CBA's (Werkwijzer Luchtvaartspecifieke MKBA's, SEO/Decisio 2021):

- Passengers: changes in consumer surplus / generalised travel costs (ticket prices and travel times). In addition, generalised travel costs are used as a proxy for welfare loss when demand can not be accomodated at Schiphol (for instance when capacity is restricted), see the appendices.
- Airlines, airports & ANSPs: changes in producer surplus / profits (scarcity rents and operational costs)
- Government: changes in tax revenues and additional expenses
- Economy: changes in business productivity (indirect economic impacts incl. agglomeration impacts)
- Society: changes in emission (including health effects) and climate impacts (external impacts)

As impacts on the European network and cross-border impacts are also relevent, we do not apply a national scope (which is generally used in a CBA)

2. Definition of cost-effectiveness

Gross economic impacts

Separately, the impacts on (gross) direct and indirect (backward) employment and value added in the Schiphol area and rest of the Netherlands are estimated*. This entails a separate assessment which partly overlaps with the previous assessment, see also the appendix. Therefore the results cannot be added and should be evaluated separately.

It should be noted that – given the fact that labour supply is tight within the Dutch economy – any change in employment within the Dutch aviation industry (direct) or at suppliers (indirect backward) will likely result in a shift in employment to other industries, not in a net change in employment. Because we assess the effect on the short-term (2024), there will be a temporary effect of friction unemployment. This means additional government costs in unemployment allowances and decreasing tax revenues.

* Effects on global supply chains, networks and related investment decisions of specific airlines are not part of this gross economic impact analysis. As this falls beyond the scope of this study.

2. Definition of cost-effectiveness

For each measure we estimate its:

- **Contribution towards the noise objective**: reduction in number of affected houses and highly annoyed persons
- **Cost-effectiveness**: cost per reduced house and highly annoyed person in the various noise contours

The cost-effectiveness is measured at various levels, going from a narrow to a broader scope:

- **Operational costs for companies in the aviation industry:**
  - Changes in operational costs of airlines, airports and ASNPs
- **Total direct costs:**
  - Changes in operational costs of airlines, airports and ASNP's
  - Changes in generalised travel costs passengers and freight
  - Changes in government costs
- **Total costs (including indirect and external costs):**
  - Changes in operational costs of airlines, airports and ASNP's
  - Changes in generalised travel costs passengers and freight
  - Changes in government costs
  - Changes in (net) external effects: climate, air quality
  - Changes in indirect economic impacts (agglomeration)

2. Definition of cost-effectiveness

The noise impact is measured in terms of reduced number of houses and highly annoyed persons within the noise contours. The noise impact is not monetised and included as a cost savings as that would mean that the same impact would be included in both sides of the equation

The appendices provide more detail on the key figures, costs, prices, assumptions and methodology used to estimate and calculate the different effects regarding the cost-effectiveness.

2. Selection of 6 measures

For each pillar in the Balanced Approach procedure we identified several measures and these were all added into a longlist (for the long list we refer to the to70 report).

From the longlist we selected those measures that met a number of criteria. These made it to the shortlist (including variants) and for each of these measures we assess its cost effectiveness.

For a more elaborate description of the selection process we refer to the To70 report.

This led to the selection of the following six measures:

Pillar	Measure	Description
1. Reduce aircraft noise at source	M1*	Stimulate airlines to use quieter aircraft (through differentiation of airport charges)
2. Land use planning and management	-	*No measures in this pillar met the set of selection criteria*
3. Noise abatement operational procedures	M7*	Extend the night regime
	M8*	Runway closure (full or during specific circumstances)
	M10*	Minimize the use of the secondary runways
4. Operating restrictions	M14*	Cap the number of annual movements (440k)
	M15*	Cap the number of movements during the night-time

**Measure abbreviation corresponds to the measures in long-list (see also report of To70)*

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3. Results: cost-effectiveness per measure

M1: Stimulate airlines to use quieter aircraft

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

M1: Stimulate airlines to use quieter aircraft

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			

M1: Stimulate airlines to use quieter aircraft

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 accompagnied by a decrease in another category or categories to ensure that total revenues do not exceed costs

Measure

- S1: Charge increase
- S2 - S3: No change
- S4 - S7: Charge decrease (by the same absolute amount as charges for category S1 increase)

As a consequence we expect that airlines replace S1 aircraft by quieter types when available in their fleets

In the short-term (until at least 2024) shifting aircraft around in the network might be the only viable way for airlines to avoid the charge increase for S1 aircraft.

In the longer term airlines – including home-based carriers – may accelerate fleet renewal through the acquisition of quieter aircraft. However, this is not part of the analysis until novemeber 2024.

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

- Ability to shift: *Are they bound to 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?*

M1: Stimulate airlines to use quieter aircraft

Assumptions

It is difficult to predict how each airline shall respond to an increase in S1 charges (and a decrease in S6-S7 charges). There is some practical evidence from airports such as Brussels and Zurich (Evangelinos et. al, 2020). Bases on this and our own expert judgement we make the following assumptions per carrier category:

- **Home-based carriers: KLM, Transavia,…**
  - 0% of S1 flights is replaced; home based carriers have no possibility to shift aircraft as all flights originate or terminate at Schiphol
- **Other large network carriers**
  - 75% of S1 flights is replaced by quieter types available within their fleets; large airlines operate extensive fleets and therefore have much flexibility to shift aircraft
- **Small network carriers**
  - 25% of S1 flights is replaced by quieter types; smaller airlines have less flexibility to switch aircraft within their fleet. Of the remaining 75% of S1 flights, half is discontinued and slots are taken over by others operating quieter S6 and S7 aircraft
- **Cargo carriers**
  - 100% of S1 cargo flights is moved to other airports due to the fact that cargo carriers operate small fleets and due to the high price sensitivity of air cargo. The slots are used for passenger services operated with S6 and S7 aircraft

M1: Stimulate airlines to use quieter aircraft

Based on the projected baseline scenario for 2024 this results in the following changes in traffic composition:

- Remaining S1 flights:
  30,495 movements
- Reallocation to quieter aircraft within own fleet:
  42,134 movements
- Reallocation to quieter aircraft to other airlines:
  12,089 movements

Due to the scarcity of airport capacity / slots, we assume that the stronger differentiation does not lead to a reduction in the number of flights, only in a change in traffic composition

In practice the lower charges for S6 and S7 aircraft may also incentivise airlines to replace aircraft in S2-S5 categories by quieter types. This is not taken into account and leads to an underestimation of the noise impact

Cargo carriers with S1 aircraft move to other airports (mainly abroad), around 1.000 full freighter movements. The assumption is that they will be replaced by S6/S7 aircraft of passengar airlines (included in the total of the reallocation to other airlines)

In Appendix B we explain more in detail the methodology used to differentiate in airport charges

M1: Stimulate airlines to use quieter aircraft

Cost estimation (see appendix A for key figures)

- **Passengers/Freight:**
  - No overall impact on generalised travel costs. Cost increases for S1 aircraft and cost decreases for S4-S7 aircraft may partly be passed-through into ticket prices but increases are compensated by decreases. This effect is a +/- PM item in our analysis.
  - 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 S6/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).
  - No overall impact on infrastructure costs: higher charges for S1 are fully compensated by lower charges for S4-S7. Some airlines benefit, others do not (esp. home-based), This effect is a +/- PM item in our analysis.
- **Airports:**
  - No overall impact on profitability: airport charges should be cost-based (increases in S1 fully compensated by decreases in S4-S7)
- **Indirect economic impacts (agglomeration effects)**
  - Less efficient operation and increase in generalised travel costs have negative economic effects on the agglomeration of Schiphol.
- **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 (local effect):**
  - 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 Planing Bureau.

Results M1: Stimulate airlines to use quieter aircraft

Total costs:

- Costs in negative terms and for the year 2024 (yearly costs)
- Generalized travel costs only for freight/cargo carriers as they move to other airports, no impact on passengers
- Net change in employed persons/FTE means an increase in government costs (unemployment allowances and foregone tax revenues)

Cost effectiveness of reduction per house/annoyed person:

- Measure in itself does not reach any noise objective
- Measure has a relatively larger impact and is more cost-effective within the Lden contours than in the Lnight contours.

Direct and indrect economic impact (gross and net effect)

	Gross effect (direct+indirect)	Net effect (short-term friction)
Employed Persons	-840	-42
FTE	-700	-35
Value added (mln. euro's)	-€ 76,2	-€ 3,8

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

	M1
Net costs	
Operational costs airlines	-€ 42,7 +/- PM
Generalised travel cost passengers/freight	-€ 19,1 +/- PM
Government costs	-€ 0,9
Direct costs	**-€ 62,7 +/- PM**
Net External effects (less flights)	
Climate effects - CO2 and non CO2	
Air quality - NoX	
Air quality - PM10	
Additional economic impact Schiphol (agglomeration)	-€ 9,3 +/- PM
Total costs (including indirect and external costs):	**-€ 72,0 +/- PM**

Results M1: Stimulate airlines to use quieter aircraft

Cost effectiveness of reduction per house/annoyed person:

- Measure in itself does not reach any noise objective
- Measure has a relatively larger impact and is more cost-effective within the Lden contours than in the Lnight contours.

With respect to baseline 500k:	Change in number of houses/persons:	Change in % of houses/persons:	*Net operational costs per reduction of:*	*Direct costs per reduction of:*	*Total costs per reduction of:*
Houses in 58 dB Lden Contour	-258	-3,6%	-€ 165.539	-€ 243.179	-€ 279.139
Houses in 48 dB Lnight Contour	-83	-1,5%	-€ 514.568	-€ 755.907	-€ 867.686
Highly annoyed persons in 48 Lden Contour	-4.088	-3,6%	-€ 10.448	-€ 15.349	-€ 17.618
Highly annoyed persons in 40 Lnight Contour	-125	-0,5%	-€ 342.052	-€ 502.479	-€ 576.783

= Noise abatement objective not achieved

= Noise abatement objective achieved

M7: Extension of the night regime

During the night time, Schiphol only operates the 2 noise preferential runways as compared to the simultaneous use of 3 or 4 runways in peak hours during the day. Extending the night period would mean that for a larger part of the day only the 2 noise preferential runways are in use

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

Current situation

Night regime: 22.40 - 06.40

Measures (two variants)

- M7a: Extension evening (+1hr): 21.40 - 06.40
- M7b: Extension evening + morning until 07:00: 21.40 - 07.00

The extensions with one hour in the late evening (and 20 minutes to 1 hour and 20 minutes in the early morning) was chosen, because these regimes are already used at Schiphol in times with surplus capacity

M7: Extension of the night regime

With only the 2 noise preferential runways in use instead of a maximum of 4, the capacity of the airport decreases in the late evening (and early morning)

This will primarily affect airlines that operate many slots during those hours

- KLM and partners
- Budget airlines / low-cost carriers

Assumptions

It is assumed that reduced airport capacity during the late evening (and early morning) translates into flight delays. The costs of these delays are included in the operational costs assessment.

Due to the scarcity of airport capacity / slots we assume that the total number of aircraft movement does not change, only the distribution over the day

Movements by airline Category and night/day

	Orginal day	Current Night	Evening extension	Morning extension	Increase Night (evening extension)	Increase Night (evening + morning)
Budget Airlines	76.556	11.025	5.335	6.403	16.360	22.764
Charters	11.490	2.166	937	1.488	3.103	4.591
European Network carriers	68.762	60	3.810	2.794	3.870	6.664
KLM and partners	271.727	6.887	6.412	15.911	13.299	29.210
Middle Eastern carriers	7.918	370	705	21	1.075	1.096
Other	20.686	773	569	316	1.342	1.658
Other Intercontinental carriers	6.435	1.794	302	437	2.096	2.533
US carriers	3.721	-	-	603	-	603
Freight/Cargo/Express	7.771	1.859	622	149	2.481	2.630
Totaal	**475.066**	**24.934**	**18.692**	**28.123**	**43.626**	**71.749**

M7: Extension of the night regime

Cost estimation

- Passengers:
  - Increase in generalised travel costs: travel time increase x time valuation for air passengers in Netherlands
- Airlines:
  - Increased operational costs: flight time increase x operational costs per block hour per business segment:
    - KLM & European network carriers: use operational costs for KLM based on its annual report
    - Non-European network carriers: use operational costs as published by the FAA for US passenger airlines
    - Cargo carriers: use operational costs as published by the FAA for US cargo airlines
    - Low-cost carriers: use operational costs for easyJet based on its annual report
  - Airlines will fully absorb increase in operational costs because of competitive market
- Airports:
  - No overall impact on profitability
- Government:
  - No effect on government expenses
- Society:
  - Climate effects and effects to air quality are not quantified as the amount of flights stay at 500k.
- Employment and value added
  - No gross impact as the total number of flight movements does not change

Results M7: Extension of the night regime

Total costs:

- Costs in negative terms and for the year 2024 (yearly costs)
- Operational costs increases when night regime is extended, because more flights are affected
- Generalised travel costs for both freight and passengers
- No government costs as jobs/FTE are not affected.
- Net external effects not calculated as they fall in the margin of error

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

	M7a evening	M7b evening + morning 7h
Net costs		
Operational costs airlines	-€ 24,3	-€ 34,5
Generalised travel cost passengers/freight	-€ 31,9	-€ 44,2
Government costs	€ 0,0	€ 0,0
Direct costs	**-€ 56,2**	**-€ 78,7**
Net External effects (less flights)		
Climate effects - CO2 and non CO2		
Air quality - NoX		
Air quality - PM10		
Additional economic impact Schiphol (agglomeration)	-€ 8,4	-€ 11,8
Total costs (including indirect and external costs):	**-€ 64,6**	**-€ 90,5**

Results M7: Extension of the night regime

Cost effectiveness of reduction per house/annoyed person:

- Measure in itself does not reach any noise objective
- Starting the night period one hour earlier (M7 evening) has no impact on Lnight.
- Starting the night period one hour earlier and extending it in the morning by 20 minutes (M7 evening + morning 7h) is the most cost-effective variant of the three

With respect to baseline 500k:	Change in number of houses/persons:	Change in % of houses/persons:	*Net operational costs per reduction of:*	*Direct costs per reduction of:*	*Total costs per reduction of:*
M7a Evening					
Houses in 58 dB Lden Contour	-100	-1,4%	-€ 242.588	-€ 561.898	-€ 646.183
Houses in 48 dB Lnight Contour	-	0,0%			
Highly annoyed persons in 48 Lden Contour	-3.378	-3,0%	-€ 7.181	-€ 16.633	-€ 19.127
Highly annoyed persons in 40 Lnight Contour	-0	0,0%			
M7b evening + morning 7h					
Houses in 58 dB Lden Contour	-228	-3,2%	-€ 151.265	-€ 344.999	-€ 396.749
Houses in 48 dB Lnight Contour	-421	-7,4%	-€ 81.920	-€ 186.841	-€ 214.867
Highly annoyed persons in 48 Lden Contour	-5.812	-5,1%	-€ 5.934	-€ 13.534	-€ 15.564
Highly annoyed persons in 40 Lnight Contour	-1.373	-5,6%	-€ 25.118	-€ 57.288	-€ 65.881
		= Noise abatement objective not achieved			
		= Noise abatement objective achieved			

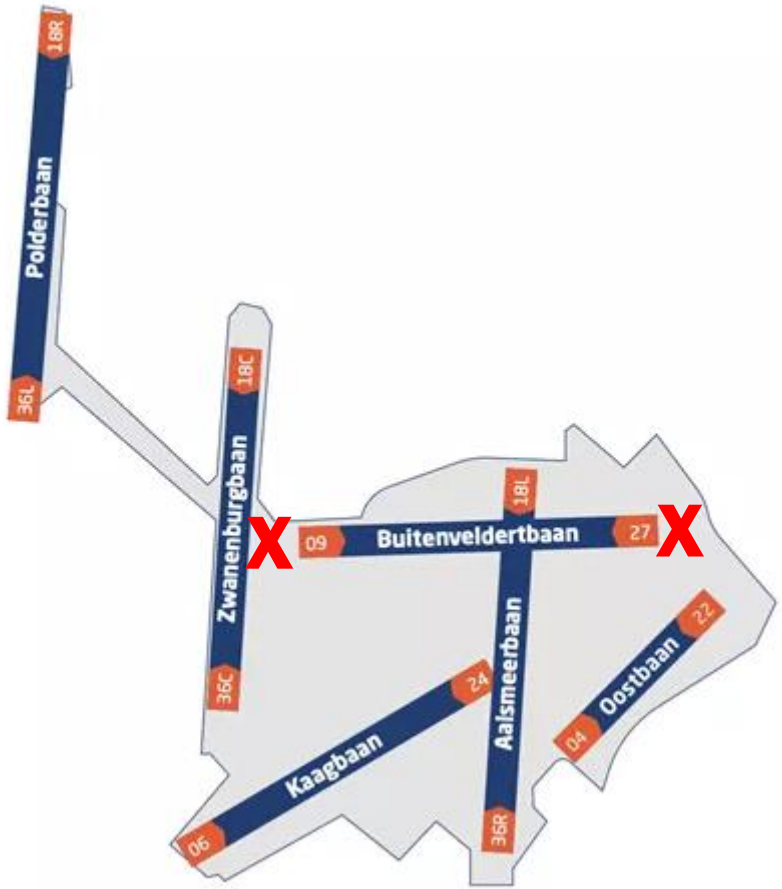
M8: Runway closure (partial)

The departure and approach routes for the Buitenveldert-runway (09-27) cross a densely populated residential area. Closure of this runway shall therefore have a relatively large impact on noise. The impact on airport operations shall be relatively limited as it is not one of the widely used preferential runways

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

Current situation

The Buitenveldert-runway is in use during specific weather conditions (strong westerly winds) and when other runways are being renovated



M8: Runway closure (partial)

In this measure the Buitenveldertbaan remains available during specific weather conditions (combination of windspeed and -direction) when the Buitenvelderbaan has the highest chance of being selected.

Flight times may increase or decrease depending on the origin/destination of the flight and the orientation of the alternative runway used

In case flights are shifted to the Polder-runway taxi-times will increase

Assumptions

Flights that currently operate from the Buitenveldert-runway are redistributed over the other runways according to the existing runway selection system

It is assumed that the total hourly and yearly capacity of Schiphol airport does not change as a result of this measure

M8: Runway closure (partial)

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 overall impact on profitability
- Society:
  - Climate effects and effects to air quality are not quantified as the amount of flights stay at 500k
- Government:
  - No effect on government expenses
- Employment and value added
  - No gross impact as the total number of flight movements does not change

Results M8: Runway closure (partial)

Total costs:

- Costs in negative terms and for the year 2024 (yearly costs)
- Operational costs increase because of increased taxi times, flight times and additional congestion
- Generalised travel costs for both freight and passengers

Cost effectiveness of reduction per house/annoyed person:

- Measure reaches noise abatement goal in 58 dB Lden contour and is relatively cost-effective.

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

	M8 - 09/27 chance method
Net costs	
Operational costs airlines	-€ 44,8
Generalised travel cost passengers/freight	-€ 58,1
Government costs	€ 0,0
Direct costs	**-€ 102,9**
Net External effects (less flights)	
Climate effects - CO2 and non CO2	
Air quality - NoX	
Air quality - PM10	
Additional economic impact Schiphol (agglomeration)	-€ 15,4
Total costs (including indirect and external costs):	**-€ 118,4**

With respect to baseline 500k:	Change in number of houses/persons:	Change in % of houses/persons:	*Net operational costs per reduction of:*	*Direct costs per reduction of:*	*Total costs per reduction of:*
M8 - 09/27 chance method					
Houses in 58 dB Lden Contour	-1.480	-20,9%	-€ 30.268	-€ 69.553	-€ 79.986
Houses in 48 dB Lnight Contour	-303	-5,3%	-€ 147.843	-€ 339.730	-€ 390.689
Highly annoyed persons in 48 Lden Contour	-2.651	-2,3%	-€ 16.898	-€ 38.830	-€ 44.654
Highly annoyed persons in 40 Lnight Contour	-937	-3,8%	-€ 47.783	-€ 109.801	-€ 126.271

= Noise abatement objective not achieved

= Noise abatement objective achieved

M10: Minimize 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

Day (06:00-23:00)

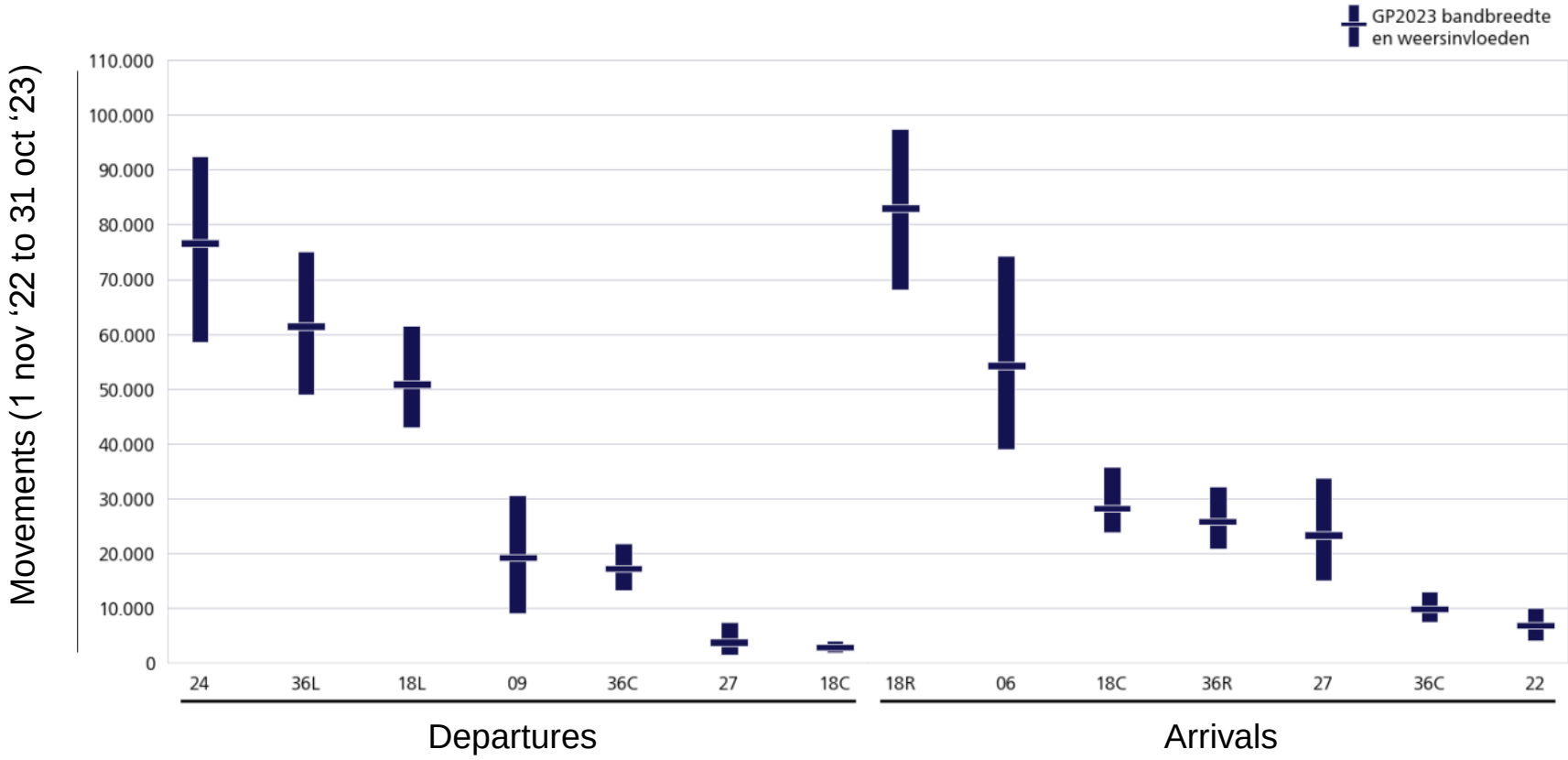
	Landings		Starts	
	L1	**L2**	**S1**	**S2**
1	06	(36R)	36L	(36C)
2	18R	(18C)	24	(18L)
3	06	(36R)	09	(36L)
4	27	(18R)	24	(18L)
5a	36R	(36C)	36L	(36C)
5b	18R	(18C)	18L	(18C)
6a	36R	(36C)	36L	(09)
6b	18R	(18C)	18L	(24)

Night

	Landings	Starts
1	06	36L
2	18R	24
3	36C	36L
4	18R	18C

M10: Minimize use of secondary runways

Expected runway use at Schiphol in operational year 2023



M10: Minimize use of secondary runways

Measure

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

This might increase the risk of delays

Flight times may increase or decrease depending on the origin/destination of the flight and the orientation of the alternative runway used

In case flights are shifted to the Polder-runway taxi-times will increase

Assumptions

It is assumed that the total hourly and yearly capacity of Schiphol airport does not change as a result of this measure

M10: 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 overall impact on profitability
- Society:
  - Climate effects and effects to air quality are not quantified as the amount of flights stay at 500k
- Government:
  - No effect on government expenses
- Employment and value added
  - No gross impact as the total number of flight movements does not change

Results M10: Minimize use of secondary runways

Total costs:

- Costs in negative terms and for the year 2024 (yearly costs)
- Total flights in 2024 stay at 500k, therefore no effect on employment and net external impacts

Cost effectiveness of reduction per house/annoyed person:

- Measure in itself does not reach any noise objective
- Very cost-effective in 48 dB Lden contour.
- No effect in Lnight as secondary runway use are already minimized during that periode

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

	M10 - reduce 2nd rwy use
Net costs	
Operational costs airlines	-€ 4,7
Generalised travel cost passengers/freight	-€ 5,0
Government costs	€ 0,0
Direct costs	**-€ 9,7**
Net External effects (less flights)	
Climate effects - CO2 and non CO2	
Air quality - NoX	
Air quality - PM10	
Additional economic impact Schiphol (agglomeration)	-€ 1,5
Total costs (including indirect and external costs):	**-€ 11,1**

With respect to baseline 500k:	Change in number of houses/persons:	Change in % of houses/persons:	*Net operational costs per reduction of:*	*Direct costs per reduction of:*	*Total costs per reduction of:*
Houses in 58 dB Lden Contour	-187	-2,6%	-€ 25.059	-€ 51.727	-€ 59.486
Houses in 48 dB Lnight Contour	-	0,0%	€ 0	€ 0	€ 0
Highly annoyed persons in 48 Lden Contour	-3.256	-2,9%	-€ 1.439	-€ 2.971	-€ 3.416
Highly annoyed persons in 40 Lnight Contour	-	0,0%	€ 0	€ 0	€ 0

= Noise abatement objective not achieved

= Noise abatement objective achieved

M14: Cap on total flight movements

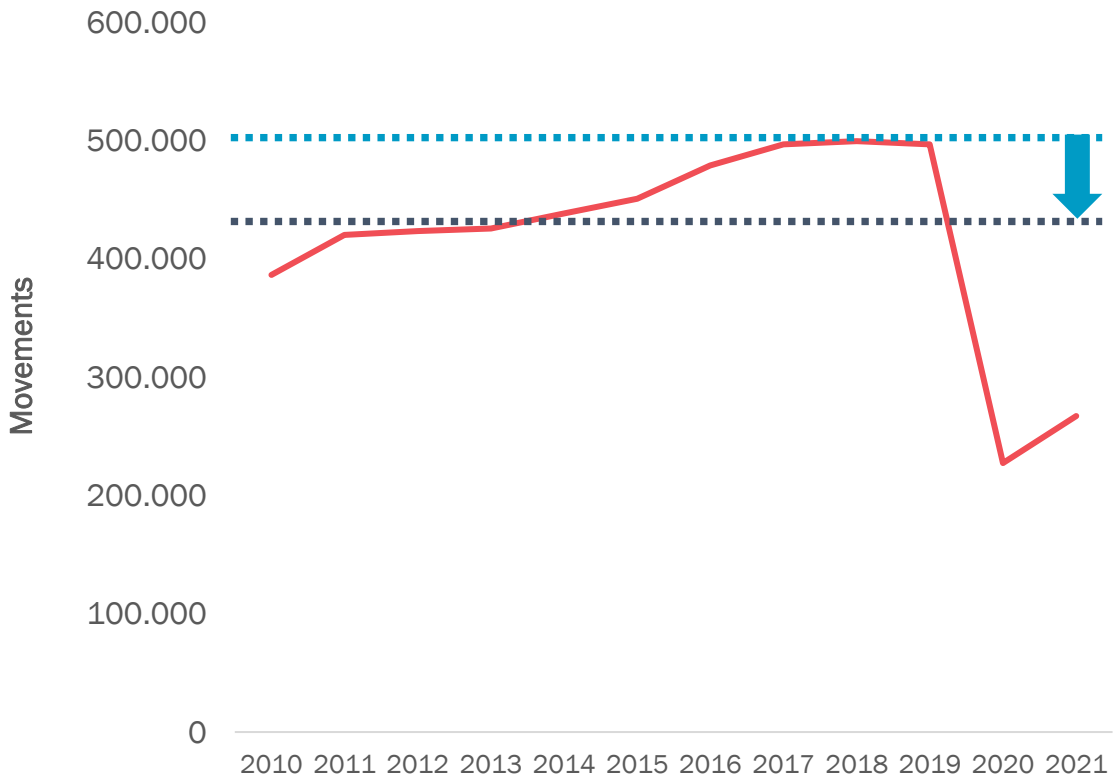
This is the measure announced by the Dutch government. According to the government a total annual capacity of 440,000 is sufficient to serve the most important destinations on the GaWC list

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

Current situation

Before the COVID-19 pandemic Schiphol was operating at its maximum capacity of 500,000 flight movements

Total flight movements at Schiphol (2010-2021)



M14: Cap on total flight movements

Measure

Reducing the annual capacity from 500,000 to 440,000 (-12%) might have a relatively large impact on noise as a larger share of traffic can be handled at the noise preferential runways

Reducing supply in a market where supply is already limited will lead to more scarcity. This means that a larger share of demand cannot be accommodated

Enhanced scarcity allows airlines to increase fares and capture scarcity rents which are paid for by the passenger (zero sum)

Consequently, price sensitive segments (leisure, transfer & cargo) are the first to substitute to other modalities and airports or choose not to travel anymore

Airlines shall use their scarce slots for those flights that contribute most to overall profitability. This could lead to a less diverse network

However, hub carrier KLM shall remain dependent on transfer traffic for operating its long-haul flights

M14: Cap on total flight movements

Home-based carriers and the airport will be faced with additional costs in terms of:

- Redundancy payments for layed off workers
- Higher depreciation of redundant assets (fleet, infrastructure)

As most of the airport's costs are fixed, the costs per aircraft movement shall increase. This will lead to higher airport charges which will be paid for by the airlines (zero sum)

Finally, there is a risk that other countries introduce retaliative measures, such as reducing the number of landing rights for Dutch carriers

Assumptions

Total number of flights is reduced from 500.000 to 440.000 and the number of night flights is reduced from 32.000 to 29.000. Airlines have to give up slots pro rata (each 12%)*.

In addition, we add as a sensitivity analysis, a scenario where the night flights are kept at 32.000 and flights and 60.000 reduction takes place during the daytime.

How airlines shall use their remaining slots depends on the contribution of each flight to overall profitability. As such information is not publicly available we made assumptions on which flights are likely most profitable for various categories of airlines.

* This is in line with the recent advice given by the Airport Coordination Netherlands (ACNL), see also the document Advies Reductie Vluchten Schiphol (ACNL, 13 februari 2023).

M14: Cap on total flight movements

- Hub carrier:
  - Short-haul: reduce frequencies on high-frequent routes (> 1500 flights per year; large share of transfer)
  - Long-haul: protect as much as possible (taking into account reduction in feeder traffic), but scrap low-frequent routes (<= 3 per week)
- Other network carriers:
  - Protect routes to/from hub(s); reduce flights to non-hub destinations (if any)
- Low-cost carriers
  - Scrap routes with low frequencies (probably low profitability)
- Charters
  - Reduce flight frequencies pro rata over all routes (frequency is less relevant than a large supply of destinations)

- Cargo carriers:
  - Scrap routes with low frequencies; protect routes to primary airport(s)

- For mixed-carriers with both a passenger and cargo operation it is furthermore assumed that part of the cargo flights will be replaced by passenger flights
  - Mixed-carriers bound to Schiphol the reduction in slots is spread 2/3 and 1/3 over passenger and cargo flights
  - Mixed-carriers which also operate cargo flights from other airports nearby the reduction in slots is spread 1/3 and 2/3 over passenger and cargo flights

- We also control for an upgauging effect for certain narrowbody aircraft as larger narrowbody aircraft will replace smaller ones on certain routes

M14: Cap on total flight movements

Cost estimation

Gray items not quantified; these items are a redistribution of a cost of one stakeholder which comes in as an additional revenue to another stakeholder. This redistribution is a zero-sum game and has no net effect on total costs.

- Passengers:
  - Remaining at Schiphol: increase in generalised travel costs: ticket price increase due to scarcity rents
  - Substituting to other modalities, airports or not travelling anymore: increase in generalised travel costs x 0.5 (so-called rule of half), see appendix C
- Airlines:
  - Increase in revenues per remaining passenger: ticket price increase due to scarcity rents (distribution from passengers, zero-sum, therefore not modelled)
  - Increase in operational costs due to lower utilisation of assets: increase in fixed costs (based on annual reports)
  - Higher costs of infrastructure due to less efficient use: increase in airport charges
- Airports:
  - Higher costs of infrastructure due to less efficient use: increase in airport charges (distribution from airlines, zero-sum, therefore not modelled)
- Employment and value added
  - Gross impact due to reduced airport activity: % reduction in passenger and cargo volumes x gross employment and value added at Schiphol
- Government:
  - In short-term unemployment allowances increase and tax revenue decrease
- Society:
  - Effect on climate and environmental effects because of net reduction of flights on global scale (also see appendix A)
  - Retaliation of other countries; hard to predict and quantify

Results M14: Cap on total flight movements

Total costs:

- Costs in negative terms and for the year 2024 (yearly costs)
- Operational costs increase significantly due to the lower utility of assets (aircraft). Operations of all airlines are affected to some extent
- Generalised travel costs also increase significantly as the demand of pax and freight flights is not accommodated at Schiphol with respect to baseline. This means welfare loss for around 4 million O/D pax and around 1.200 full freight flights as they have to go other airports or choose other modalities, see appendix C.
- Cap on total flights reduces gross employment and value added.
- 440k/32k scenario less restrictive at night which translates intro somewhat lowver costs. More use of widebody aircraft causes slightly smaller (positive) external effects compared to 440k/29k.

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

	M14 - 440k/29k	M14 - 440k/32k
Net costs		
Operational costs airlines	-€ 236,2 +/- PM	-€ 219,7+/- PM
Generalised travel cost passengers/freight	-€ 620,6 - PM	-€ 613,9- PM
Government costs	-€ 14,4	-€ 14,4
Airport authorities	- PM	- PM
Direct costs	**-€ 871,2 - PM**	**-€ 847,9- PM**
Net External effects (less flights)		
Climate effects - CO2 and non CO2	€ 90,9	€ 84,6
Air quality - NoX	€ 4,3	€ 4,3
Air quality - PM10	€ 0,4	€ 0,4
Additional economic impact Schiphol (agglomeration)	-€ 128,5 +/- PM	-€ 125,0 +/- PM
Total costs (including indirect and external costs):	**-€ 904,0 - PM**	**-€ 883,7 - PM**

Direct and indrect economic impact (gross and net effect)

	Gross effect (direct+indirect)	Net effect (short-term friction)
Employed Persons	-13.685	-684
FTE	-11.196	-560
Value added (mln. euro's)	-€ 1.282,5	-€ 64,1

Results M14: Cap on total flight movements

Cost effectiveness of reduction per house/annoyed person:

- Measure in itself does not reach any noise objective
- Cost effectiveness is relatively low, but the cost effectiveness per highly annoyed person in 48 dB Lden are in the same order of magnitude as other measures.

With respect to baseline 500k:	Change in number of houses/persons:	Change in % of houses/persons:	*Net operational costs per reduction of:*	*Direct costs per reduction of:*	*Total costs per reduction of:*
M14 - 440k / 29k at night capacity restriction					
Houses in 58 dB Lden Contour	-1.086	-15,3%	-€ 217.506	-€ 802.227	-€ 832.450
Houses in 48 dB Lnight Contour	-752	-13,2%	-€ 314.111	-€ 1.158.535	-€ 1.202.181
Highly annoyed persons in 48 Lden Contour	-18.991	-16,7%	-€ 12.438	-€ 45.874	-€ 47.603
Highly annoyed persons in 40 Lnight Contour	-2.624	-10,8%	-€ 90.036	-€ 332.080	-€ 344.591
M14 - 440k / 32k at night capacity restriction					
Houses in 58 dB Lden Contour	-991	-14,0%	-€ 221.652	-€ 855.639	-€ 891.747
Houses in 48 dB Lnight Contour	-	0,0%			
Highly annoyed persons in 48 Lden Contour	-15.863	-13,9%	-€ 13.847	-€ 53.452	-€ 55.708
Highly annoyed persons in 40 Lnight Contour	-	0,0%			

= Noise abatement objective not achieved

= Noise abatement objective achieved

M15: Cap on night movements

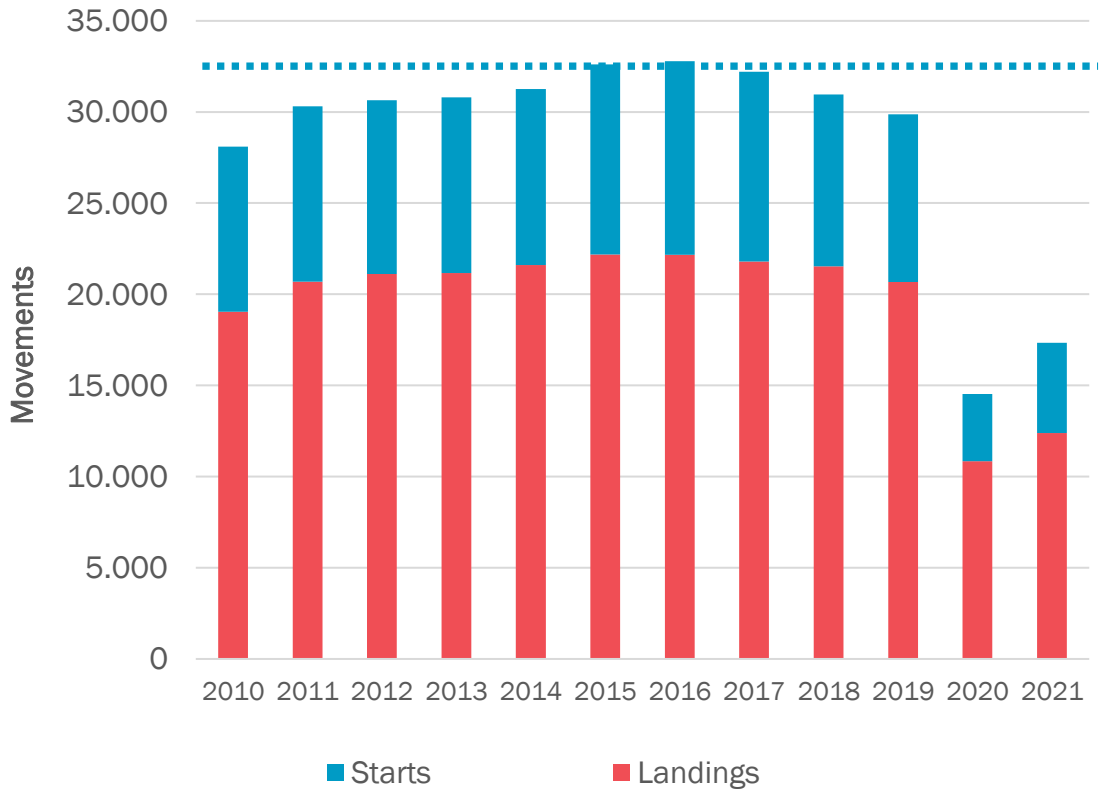
Night flights lead to sleep disturbance which might cause health impacts. Reducing the number of night flights could therefore be an effective way to reduce the noise impact around the airport

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

Current situation

Schiphol is allowed to operate a maximum of 32.000 night flights. Around one third of all night flights consists of starts and two thirds of landings

Night movements at Schiphol (2010-2021)



M15: Cap on night movements

Measure (three variants)

Reducing the annual capacity during the night from 32.000 to:

- 29.000
- 27.000
- 25.000

Reducing supply during the night might reduce the utilisation of aircraft; airlines need more aircraft to operate the same amount of flights

Airlines may shift night flights to the late evening and/or early morning. For the hub carrier this may lead to longer transfer times and therefore a less attractive transfer product

However, shifting flights from the night to the daytime may lead to more convenient departure and arrival times for passengers

Assumptions

Airlines have to give up night slots pro rata*, but slots can be shifted to other moments of the day (no decrease in total capacity).

How airlines shall use their remaining slots depends on the contribution of each flight to overall profitability. As such information is not publicly available we assume that airlines reduce their night flights pro rata over routes

* This is in line with the recent advice given by the Airport Coordination Netherlands (ACNL), see also the document Advies Reductie Vluchten Schiphol (ACNL, 13 februari 2023).

M15: Cap on night movements

Cost estimation

Gray items not quantified; these items are a redistribution of a cost of one stakeholder which comes in as an additional revenue to another stakeholder. This redistribution is a zero-sum game and has no net effect on total costs.

- Passengers:
  - Increase in generalised travel costs : average increase in transfer times x value of time
  - More convenient departure/arrival times
- Airlines:
  - Increase in operational costs due to lower utilisation of assets: increase in fixed costs (based on annual reports)
  - Lower labour costs: reduction in hours worked during the night x wage premium
- Airports:
  - Lower labour costs: reduction in hours worked during the night x wage premium
- Society:
  - Lower labour income for workers: reduction in hours worked during the night x wage premium (distribution from airlines, zero-sum, therefore not modelled)
- Government:
  - No effect on government expenses
- Employment and value added
  - No gross impact as the total number of flight movements does not change

Results M15: Cap on night movements

Total Costs:

- Costs in negative terms and for the year 2024 (yearly costs)
- Operational costs increase when a more stringent cap during the night is applied.
- Generalised travel costs increase signicantly when moving to 25k as waiting times due to less efficient connections for passengers and freight are increased.

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

	M15 - 500k/29k	M15 - 500k/27k	M15 - 500k/25k
Net costs			
Operational costs airlines	-€ 10,8	-€ 19,0	-€ 30,9
Generalised travel cost passengers/freight	-€ 8,0	-€ 14,9	-€ 33,4
Government costs	€ 0,0	€ 0,0	€ 0,0
Direct costs	**-€ 18,8**	**-€ 33,9**	**-€ 64,2**
Net External effects (less flights)			
Climate effects - CO2 and non CO2			
Air quality - NoX			
Air quality - PM10			
Additional economic impact Schiphol (agglomeration)	-€ 2,8	-€ 5,1	-€ 9,6
Total costs (including indirect and external costs):	**-€ 21,6**	**-€ 39,0**	**-€ 73,9**

Results M15: Cap on night movements

Cost effectiveness of reduction per house/annoyed person:

- Variants with 27,000 and 25,000 night flights reach the noise objectives for Lnight. However neither variant contributes significantly to the noise objectives for Lden (as expected)
- Measure is quite cost effective especially for the highly annoyed in the 48 dB Lden contour and 40 db Lnight contour.

With respect to baseline 500k:	Change in number of houses/persons:	Change in % of houses/persons:	*Net operational costs per reduction of:*	*Direct costs per reduction of:*	*Total costs per reduction of:*
M15 - 500k/29k					
Houses in 58 dB Lden Contour	-991	-3,4%	-€ 44.988	-€ 78.566	-€ 90.351
Houses in 48 dB Lnight Contour	-	-13,2%	-€ 14.298	-€ 24.970	-€ 28.715
Highly annoyed persons in 48 Lden Contour	-15.863	-2,8%	-€ 3.423	-€ 5.977	-€ 6.874
Highly annoyed persons in 40 Lnight Contour	-	-10,8%	-€ 4.098	-€ 7.157	-€ 8.231
M15 - 500k/27k					
Houses in 58 dB Lden Contour	-239	-4,9%	-€ 55.100	-€ 98.307	-€ 113.053
Houses in 48 dB Lnight Contour	-752	-22,2%	-€ 15.087	-€ 26.917	-€ 30.955
Highly annoyed persons in 48 Lden Contour	-3.141	-4,6%	-€ 3.651	-€ 6.514	-€ 7.491
Highly annoyed persons in 40 Lnight Contour	-2.624	-18,6%	-€ 4.205	-€ 7.502	-€ 8.628
M15 - 500k/25k					
Houses in 58 dB Lden Contour	-345	-6,0%	-€ 72.442	-€ 150.760	-€ 173.374
Houses in 48 dB Lnight Contour	-1.260	-30,4%	-€ 17.828	-€ 37.102	-€ 42.667
Highly annoyed persons in 48 Lden Contour	-5.207	-6,4%	-€ 4.204	-€ 8.749	-€ 10.061
Highly annoyed persons in 40 Lnight Contour	-4.521	-26,5%	-€ 4.778	-€ 9.944	-€ 11.435

= Noise abatement objective not achieved

= Noise abatement objective achieved

Overview results measures

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

With respect to baseline 500k:	M1 – Stimulate Fleet renewal	M7a evening	M7b evening + morning 7h	M8 - 09/27 chance method	M10 - reduce 2nd rwy use	M14 - 440k/29k	M14 - 440k/32k	M15 - 500k/29k	M15 - 500k/27k	M15 - 500k/25k
Net costs										
Operational costs airlines	-€ 42,7 +/- PM	-€ 24,3	-€ 34,5	-€ 44,8	-€ 4,7	-€ 236,2 +/-PM	-€ 219,7 +/-PM	-€ 10,8	-€ 19,0	-€ 30,9
Generalised travel cost passengers/freight	-€ 19,1 +/- PM	-€ 31,9	-€ 44,2	-€ 58,1	-€ 5,0	-€ 620,6 -PM	-€ 613,9 -PM	-€ 8,0	-€ 14,9	-€ 33,4
Government costs	-€ 0,9	€ 0,0	€ 0,0	€ 0,0	€ 0,0	-€ 14,4	-€ 14,4	€ 0,0	€ 0,0	€ 0,0
Airport authorities						- PM	- PM			
Direct costs	**-€ 62,7 +/- PM**	**-€ 56,2**	**-€ 78,7**	**-€ 102,9**	**-€ 9,7**	**-€ 871,2 -PM**	**-€ 847,9 -PM**	**-€ 18,8**	**-€ 33,9**	**-€ 64,2**
Net External effects (less flights)										
Climate effects - CO2 and non CO2						€ 90,9	€ 84,6			
Air quality - NoX						€ 4,3	€ 4,3			
Air quality - PM10						€ 0,4	€ 0,4			
Additional economic impact Schiphol (agglomeration)	-€ 9,3 +/- PM	-€ 8,4	-€ 11,8	-€ 15,4	-€ 1,5	-€ 128,5 +/- PM	-€ 125,0 +/- PM	-€ 2,8	-€ 5,1	-€ 9,6
Total costs (including indirect and external costs):	**-€ 72,0 +/- PM**	**-€ 64,6**	**-€ 90,5**	**-€ 118,4**	**-€ 11,1**	**-€ 904,0 - PM**	**-€ 883,7 - PM**	**-€ 21,6**	**-€ 39,0**	**-€ 73,9**

Overview results measures

Costs in euro's with respect to baseline (500k)

With respect to baseline 500k:	M1 - Stimulate Fleet renewal	M7a evening	M7b evening + morning 7h	M8 - 09/27 chance method	M10 - reduce 2nd rwy use	M14 - 440k/29k	M14 - 440k/32k	M15 - 500k/29k	M15 - 500k/27k	M15 - 500k/25k
Change in % of houses/persons:										
Houses in 58 dB Lden Contour	-3,6%	-1,4%	-3,2%	-20,9%	-2,6%	-15,3%	-14,0%	-3,4%	-4,9%	-6,0%
Houses in 48 dB Lnight Contour	-1,5%	0,0%	-7,4%	-5,3%	0,0%	-13,2%	0,0%	-13,2%	-22,2%	-30,4%
Highly annoyed persons in 48 Lden Contour	-3,6%	-3,0%	-5,1%	-2,3%	-2,9%	-16,7%	-13,9%	-2,8%	-4,6%	-6,4%
Highly annoyed persons in 40 Lnight Contour	-0,5%	0,0%	-5,6%	-3,8%	0,0%	-10,8%	0,0%	-10,8%	-18,6%	-26,5%
Net operational costs *per reduction of (wrt baseline 500k in euro's):*										
Houses in 58 dB Lden Contour	-€ 165.539	-€ 242.588	-€ 151.265	-€ 30.268	-€ 25.059	-€ 217.506	-€ 221.652	-€ 44.988	-€ 55.100	-€ 72.442
Houses in 48 dB Lnight Contour	-€ 514.568		-€ 81.920	-€ 147.843		-€ 314.111	€ 0	-€ 14.298	-€ 15.087	-€ 17.828
Highly annoyed persons in 48 Lden Contour	-€ 10.448	-€ 7.181	-€ 5.934	-€ 16.898	-€ 1.439	-€ 12.438	-€ 13.847	-€ 3.423	-€ 3.651	-€ 4.204
Highly annoyed persons in 40 Lnight Contour	-€ 342.052		-€ 25.118	-€ 47.783		-€ 90.036	€ 0	-€ 4.098	-€ 4.205	-€ 4.778
Direct costs *per reduction of (wrt baseline 500k in euro's) :*										
Houses in 58 dB Lden Contour	-€ 243.179	-€ 561.898	-€ 344.999	-€ 69.553	-€ 51.727	-€ 802.227	-€ 855.639	-€ 78.566	-€ 98.307	-€ 150.760
Houses in 48 dB Lnight Contour	-€ 755.907		-€ 186.841	-€ 339.730		-€ 1.158.535		-€ 24.970	-€ 26.917	-€ 37.102
Highly annoyed persons in 48 Lden Contour	-€ 15.349	-€ 16.633	-€ 13.534	-€ 38.830	-€ 2.971	-€ 45.874	-€ 53.452	-€ 5.977	-€ 6.514	-€ 8.749
Highly annoyed persons in 40 Lnight Contour	-€ 502.479		-€ 57.288	-€ 109.801		-€ 332.080		-€ 7.157	-€ 7.502	-€ 9.944
Total costs *per reduction of (wrt baseline 500k) :*										
Houses in 58 dB Lden Contour	-€ 279.139	-€ 646.183	-€ 396.749	-€ 79.986	-€ 59.486	-€ 832.450	-€ 891.747	-€ 90.351	-€ 113.053	-€ 173.374
Houses in 48 dB Lnight Contour	-€ 867.686		-€ 214.867	-€ 390.689		-€ 1.202.181		-€ 28.715	-€ 30.955	-€ 42.667
Highly annoyed persons in 48 Lden Contour	-€ 17.618	-€ 19.127	-€ 15.564	-€ 44.654	-€ 3.416	-€ 47.603	-€ 55.708	-€ 6.874	-€ 7.491	-€ 10.061
Highly annoyed persons in 40 Lnight Contour	-€ 576.783		-€ 65.881	-€ 126.271		-€ 344.591		-€ 8.231	-€ 8.628	-€ 11.435

= Noise abatement objective not achieved

= Noise abatement objective achieved

Overview results measures

Conclusions per pillar:

- **Pillar 1: reduction at source**
  - M1 – stimulate use of quieter aircraft – is cost-effective in the 48 dB Lden contour by the same order of magnitude as the other measures. M1 is relatively less cost-effective considering the other noise abatement objectives.
- **Pillar 2: Land use planning and management**
  - No measures included
- **Pillar 3: Operational procedures**
  - M10 – Reduce secondary runway use - is most cost-effective during daytime, 58/48 dB Lden contour
  - All M7 variant – extension of night regime - are relatively cost-effective in the highly annoyed 48 dB Lden Contour. In particular M7, evening and morning 7h. M7 is less cost-effective considering the other noise abatement objectives (Lnight and 58 Lden contour)
  - M8 – closure of Buitenveldertbaan – is most cost-effective in the 58 Lden contour

Pillar 4: Operating restrictions

- All M15 variants – capacity restriction during the night - are most cost-effective during nighttime, 48/40 Lnight contour
- M14 – reduction to 440k flights - has the highest total net costs by far. The cost-effectiveness in the 48 dB Lden contour is in the same order of magnitude as the other measures

None of the measures meets the four noise abatement objectives on its own. Combinations of measures are therefore necessary. The next section shows the impact of various combinations.

Overview results measures

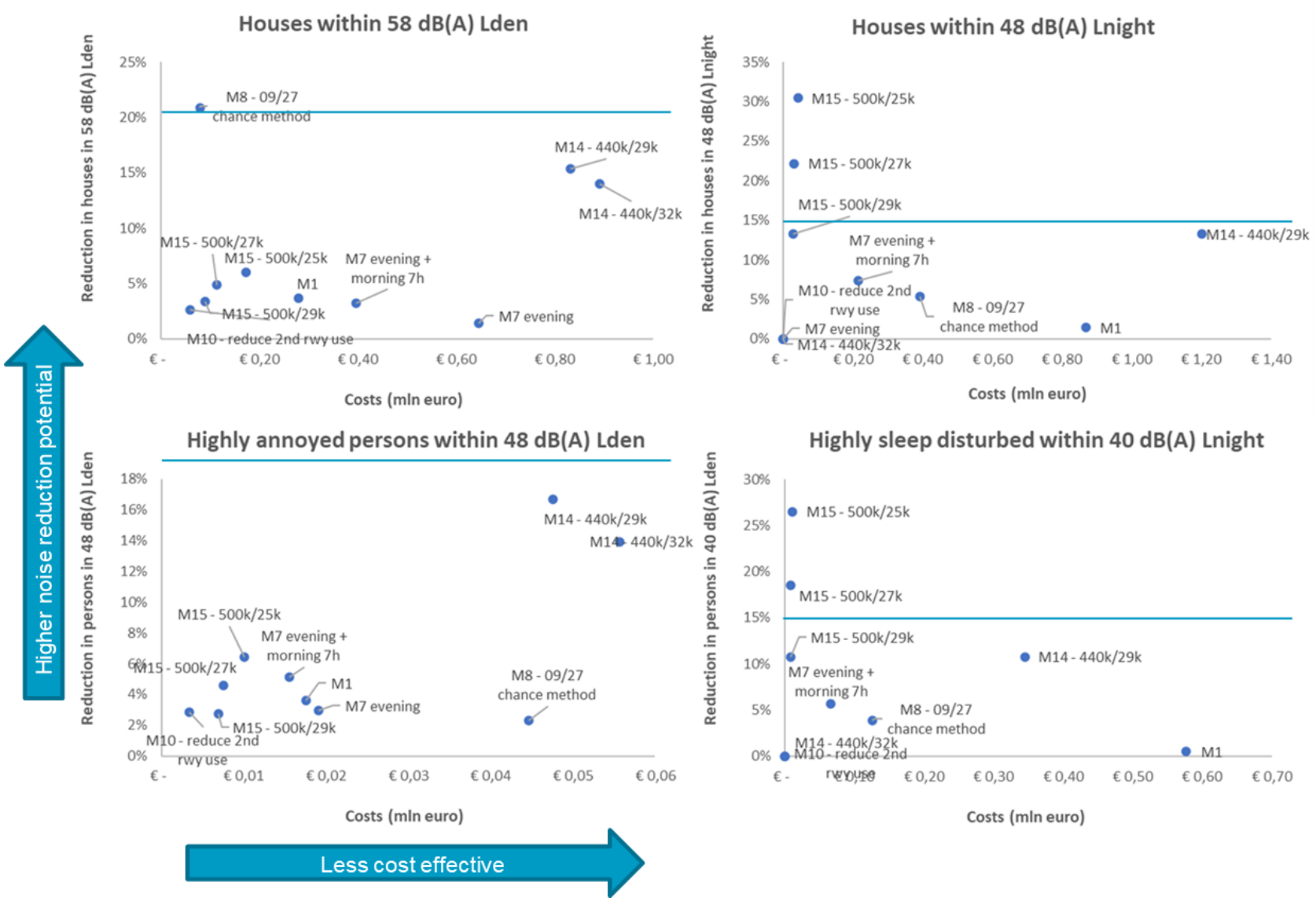
Conclusions of noise objective indicators:

- Houses within 58db(A) Lden
  - Partial closure of runway Buitenveldertbaan highly cost effective and contributes most to objective
  - Minimizing use of secondary runways most cost-effective, but contributes little to objective
  - Cap on number of total movements least cost-effective
- Houses within 48dB(A) Lnight
  - Cap on number of night flights most cost-effective and contributes significantly to objective
  - Cap on number of total movements least cost-effective
- Highly annoyed persons within 48db(A) Lden
  - Minimizing use of secondary runways most cost-effective, but contributes little to objective
  - Cap on number of night flights highly cost-effective and contributes more to objective
  - Cap on number of total movements least cost-effective, but contributes most to objective
- Highly sleep disturbed persons within 40 db(A) Lnight
  - Cap on number of night flights most cost-effective and contributes significantly to objective
  - Runway closure also highly cost effective and contributes to objectuve
  - Cap on number of movements and stimulating use of quieter aircraft least cost-effective

Overview results measures

Horizontal axis: Total costs to society per reduction of house or person within dB (a) contour in mln. of euros.

Vertical axis: Percentage reduction of houses or persons with dB (a) contour.



Overview results measures

Overall conclusions

- Minimizing use of secondary runways is most cost-effective for reducing noise during the day (Lden contours), but contributes little to objective
- Cap on number of night flights most cost-effective during the night (Lnight contours) and contributes significantly to objective
- Cap on number of night flights highly cost-effective during the day (Lden contours) and contributes more to objective
- Partial runway closure highly cost effective for houses during the day (Lden contrours) and contributes most to objective for houses
- Partial runway closure highly cost effective during the night (Lnight contrours) and contributes significantly to objective
- Cap on number of total movements least cost-effective during the day and night but contributes significantly to objective during the day and also during the night.

4. Results of cost-effectiveness of combination of measures

Combinations of measures

The previous section showed that there is no single measure with which all four noise objectives can be reached. Therefore a combination of measures is necessary. In coordination with the Ministry of Infstructure and Water Management five combinations of measures were compiled. Subsequently their combined impact on noise and cost-effectiveness was assessed

Combining different measures into a ‘package’ of measures is not simply adding up all the effects on noise abatement and costs associated with those measures. There is the risk of double counting as the combined effect of different measures have overlapping effects on noise. This will have an effect on cost-effectiveness as a combined effect might reduce cost-effectiveness

In addition, combining measures also has direct impact on operational (in)efficiencies. For instance, congestion on the airport might increase in combinations impacting the operation of airlines. This will have an impact on passenger and freight generalized travel time costs. This also impacts the productivity, business environment and location factor of the agglomeration of Schiphol

Combination A: Starts with the most cost-effective measure to the least cost-effective. The capacity restriction M14 will not be part of this combination

Combination B: Starts with the most cost-effective measure, but leaves M15 as capacity constraint in the night out of the combination. At the end capacity restriction M14 – 440k/29k is implemented as the last measure.

Combination C: Again starting with the most cost-effective measures but leaving the capacity constraints as a last resort now choosing voor M15 – 500k/25k.

Combination D: In this combination only one operational procedures is chosen to implement. As more operational procedures might lead to practical difficulties with airport authorities (LVNL). The last resort is the capacity restriction M14 – 440k/29k

Combination E: Also implementing only one operational procedure and a capacity restriction in the night, M15 – 500k/27k

See next slide for full combinations and intermediate steps

Combinations of measures

Combination	Measures	Intermediate steps:
A	M10 - reduce 2nd rwy use	
	M15 - 500k/29k	T1 – M10 & M15
	M7 evening + morning 7h	T2 – M10 & M15 & M7
	M8 - 09/27 chance method	T3 – M10 & M15 & M7 & M8
	M1 – Stimulate airlines to use quieter a/c	T4 – M10 & M15 & M7 & M8 & M1
B	M10 - reduce 2nd rwy use	
	M7 evening + morning 7h	T5 M10 & M7
	M8 - 09/27 chance method	T6 M10 & M7 & M8
	M1 – Stimulate airlines to use quieter a/c	T7 M10 & M7 & M8 & M1
	M14 - 440k/29k	T8 M10 & M7 & M8 & M1 & M14
C	M10 - reduce 2nd rwy use	
	M7 evening + morning 7h	T5
	M8 - 09/27 chance method	T6
	M1 – Stimulate airlines to use quieter a/c	T7
	M15 - 500k/25k	T9 - M10 & M7 & M8 & M1 & M15
D	M7 evening + morning 7h	
	M1 – Stimulate airlines to use quieter a/c	T10 – M7 & M1
	M14 - 440k/29k	T11 - M7 & M1 & M14
E	M7 evening only	
	M15 - 500k/27k	T12 – M7 & M15

Combination A – total costs

- Combining M10 and M15 increases traffic and congestion and travel/waiting times during the day for affected flights in T1.
- Including M7b in T2 increases congestion and travel times further for affected flights
- Adding the last (3rd) operational measure, M8 closing of runway Buitenveldert, in T3 gives adds more congestion and stress to the operation and travel times of airlines and passengers, respectively.
- Including M1 does not increase congestion but does decrease the efficiency of operation of airlines in combination A.

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

	M10 M10 - reduce 2nd rwy use	T1 M10 - reduce 2nd rwy use M15 - 500k/29k	T2 M10 - reduce 2nd rwy use M15 - 500k/29k M7b evening + morning 7h	T3 M10 - reduce 2nd rwy use M15 - 500k/29k M7b evening + morning 7h M8 - 09/27 chance method	COMBI - A M10 - reduce 2nd rwy use M15 - 500k/29k M7b evening + morning 7h M8 - 09/27 chance method M1 – Stimulate airlines to use quieter a/c
Net costs					
Operational costs airlines	-€ 4,7	-€ 14,0	-€ 52,1	-€ 101,8	-€ 144,1 +/- PM
Generalised travel cost passengers/freight	-€ 5,0	-€ 9,4	-€ 55,9	-€ 120,1	-€ 137,7 +/- PM
Government costs	€ 0,0	€ 0,0	€ 0,0	€ 0,0	-€ 0,9
Airport Authorities					
Direct costs	**-€ 9,7**	**-€ 23,4**	**-€ 108,0**	**-€ 221,9 +/- PM**	**-€ 282,7 +/- PM**
Net External effects (less flights)					
Climate effects - CO2 and non CO2					
Air quality - NoX					
Air quality - PM10					
Additional economic impact Schiphol (agglomeration)	-€ 1,5	-€ 3,5	-€ 16,2	-€ 33,3 +/- PM	-€ 42,3 +/- PM
Total costs (including indirect and external costs):	**-€ 11,1**	**-€ 26,9**	**-€ 124,2**	**-€ 255,2**	**-€ 325,0 +/- PM**

Direct and indirect economic impact (gross and net effect) Combination A

	Gross effect (direct+indirect)	Net effect (short-term friction)
Employed Persons	-840	-42
FTE	-700	-35
Value added (mln. euro's)	-€ 76,2	-€ 3,8

Combination A – cost effectiveness

- Combination A fullfills three of the four noise abatement goals, only the goal of highly annoyed persons in 48 dB Lden Contour is not met
- In T1 cost-effectiveness only decreases slightly when combining M10 with M15.
- Adding M7b in T2 decreases cost-effectiveness significantly, but the noise abatement goals at night are almost fully accomplished.
- In T3, adding M8 is very cost-effective in the higher 58 dB Lden contour and now also meets this goal. However, it decreases cost-effectivness during the night.

With respect to baseline 500k:	Change in number of houses/persons:	Change in % of houses/persons:	***Net operational costs*** *per reduction of:*	***Direct costs*** *per reduction of:*	***Total costs*** *per reduction of:*
M10 - reduce 2nd rwy use					
Houses in 58 dB Lden Contour	-187	-2,6%	-€ 25.059	-€ 51.727	-€ 59.486
Houses in 48 dB Lnight Contour	-	0,0%	€ 0	€ 0	€ 0
Highly annoyed persons in 48 Lden Contour	-3.256	-2,9%	-€ 1.439	-€ 2.971	-€ 3.416
Highly annoyed persons in 40 Lnight Contour	-	0,0%	€ 0	€ 0	€ 0
T1 - reduce 2nd rwy use, M15 - 500k/29k					
Houses in 58 dB Lden Contour	-405	-5,7%	-€ 34.577	-€ 57.664	-€ 66.313
Houses in 48 dB Lnight Contour	-790	-13,9%	-€ 17.726	-€ 29.562	-€ 33.996
Highly annoyed persons in 48 Lden Contour	-6.288	-5,5%	-€ 2.227	-€ 3.714	-€ 4.271
Highly annoyed persons in 40 Lnight Contour	-2.755	-11,3%	-€ 5.082	-€ 8.476	-€ 9.747
T2: M10 - reduce 2nd rwy use, M15 - 500k/29k, M7b evening + morning 7h					
Houses in 58 dB Lden Contour	-600	-8,5%	-€ 86.761	-€ 179.957	-€ 206.950
Houses in 48 dB Lnight Contour	-1.172	-20,6%	-€ 44.417	-€ 92.128	-€ 105.947
Highly annoyed persons in 48 Lden Contour	-11.517	-10,1%	-€ 4.520	-€ 9.375	-€ 10.782
Highly annoyed persons in 40 Lnight Contour	-3.525	-14,5%	-€ 14.769	-€ 30.634	-€ 35.229
T3: M10 - reduce 2nd rwy use, M15 - 500k/29k, M7b evening + morning 7h, M8 - 09/27 chance method					
Houses in 58 dB Lden Contour	-2.268	-32,0%	-€ 44.895	-€ 97.835	-€ 112.510
Houses in 48 dB Lnight Contour	-1.380	-24,3%	-€ 73.784	-€ 160.790	-€ 184.908
Highly annoyed persons in 48 Lden Contour	-16.029	-14,1%	-€ 6.352	-€ 13.843	-€ 15.920
Highly annoyed persons in 40 Lnight Contour	-4.449	-18,3%	-€ 22.886	-€ 49.873	-€ 57.354
Combination A: M10 - reduce 2nd rwy use, M15 - 500k/29k, M7b evening + morning 7h, M8 - 09/27 chance method, M1 – Stimulate airlines to use quieter a/c					
Houses in 58 dB Lden Contour	-2.512	-35,5%	-€ 57.381	-€ 112.549	-€ 129.379
Houses in 48 dB Lnight Contour	-1.459	-25,7%	-€ 98.795	-€ 193.779	-€ 222.755
Highly annoyed persons in 48 Lden Contour	-20.035	-17,6%	-€ 7.195	-€ 14.112	-€ 16.222
Highly annoyed persons in 40 Lnight Contour	-4.531	-18,6%	-€ 31.814	-€ 62.401	-€ 71.731

= Noise abatement objective not achieved

= Noise abatement objective achieved

Combination B and C – total costs

- T6 is a combination of all three operational procedures in pillar 3. Just like in combination A this creates additional congestion and travel/waiting times for airlines and passengers respectively.
- However, in combination B adding the capacity restriction M14 440k/29k actually reduces congestion, traffic and travel times at Schiphol airport with respect to intermediate steps T6 and T7.
- Adding M1 in T7 only increases costs and ineffeciences for airlines.
- In combination B, capacity restriction M14 – 440k/29k is added. This creates negative generalized travel time costs for passengers in particular. Therefore, total net costs increase almost fourfold.
- In combination C, capacity restriction in the night M15 – 500k/25k is added. This increases total direct costs with a factor of 1.5. But flights are kept at 500k so the welfare loss for passengers and freight is lower.

	M10 M10 - reduce 2nd rwy use	T5 M10 - reduce 2nd rwy use M7b evening + morning 7h	T6 M10 - reduce 2nd rwy use M7b evening + morning 7h M8 - 09/27 chance method	T7 M10 - reduce 2nd rwy use M7b evening + morning 7h M8 - 09/27 chance method M1 – Stimulate airlines to use quieter a/c	COMBI - B M10 - reduce 2nd rwy use M7b evening + morning 7h M8 - 09/27 chance method M1 – Stimulate airlines to use quieter a/c M14 - 440k/29k	COMBI - C M10 - reduce 2nd rwy use M7b evening + morning 7h M8 - 09/27 chance method M1 – Stimulate airlines to use quieter a/c M15 - 500k/25k
Net costs						
Operational costs airlines	-€ 4,7	-€ 39,2	-€ 88,9	-€ 131,2 +/- PM	-€ 349,5 +/- PM	-€ 184,6 +/- PM
Generalised travel cost passengers/freight	-€ 5,0	-€ 49,5	-€ 113,5	-€ 131,2+/- PM	-€ 735,8 – PM	-€ 194,2 +/- PM
Government costs	€ 0,0	€ 0,0	€ 0,0	-€ 0,9	-€ 15,3	-€ 0,9
Airport Authorities					- PM	
Direct costs	**-€ 9,7**	**-€ 88,7**	**-€ 202,4**	**-€ 263,2 +/- PM**	**-€ 1.100,7 - PM**	**-€ 379,6 +/- PM**
Net External effects (less flights)						
Climate effects - CO2 and non CO2					€ 90,9	
Air quality - NoX					€ 4,3	
Air quality - PM10					€ 0,4	
Additional economic impact Schiphol (agglomeration)	-€ 1,5	-€ 13,3	-€ 30,4	-€ 39,4 +/- PM	-€ 162,8 +/-PM	-€ 56,8 +/- PM
Total costs (including indirect and external costs):	**-€ 11.1**	**-€ 102.0**	**-€ 232.8**	**-€ 302.6 +/- PM**	**-€ 1.167,8 - PM**	**-€ 436,4 +/- PM**

Direct and indirect economic impact (gross and net effect)

	Combination B		Combination C	
	Gross effect (direct+indirect)	Net effect (short-term friction)	Gross effect (direct+indirect)	Net effect (short-term friction)
Employed Persons	-13.685	-684	-840	-42
FTE	-11.196	-560	-700	-35
Value added (mln. euro's)	-€ 1.282,5	-€ 64,1	-€ 76,2	-€ 3,8

Combination B and C – cost effectiveness

- In combination B and C all four noise abatement goals are achieved.
- Combination C is more cost-effective than combination B, but overshoots the Lnight target significantly by a factor of two
- Combination B overshoots the Lden targets significantly
- Adding M7, extension of night regime evening+ morning 7h, in intermediate step T5 decreases cost-effectiveness signficantly
- In intermediate step T6 adding M8, closure of the Buitenvelderbaan, increases cost-effectiveness during the day in the higher 58db Lden contour.
- In step T7 adding M1, stimulating quieter aircraft, does not affect the cost-effectiveness significantly in the 48 Lden contour. However, it does decrease the cost-effectiveness for the other goals.
- Adding M15 -500k/25k in combination C increases cost-effectiveness in the night signficantly for all noise abatement goals with respect to T7

With respect to baseline 500k:	Change in number of houses/persons:	Change in % of houses/persons:	***Net operational costs*** *per reduction of:*	*Direct costs per reduction of:*	*Total costs per reduction of:*
M10 - reduce 2nd rwy use					
Houses in 58 dB Lden Contour	-187	-2,6%	-€ 25.059	-€ 51.727	-€ 59.486
Houses in 48 dB Lnight Contour	-	0,0%	€ 0	€ 0	€ 0
Highly annoyed persons in 48 Lden Contour	-3.256	-2,9%	-€ 1.439	-€ 2.971	-€ 3.416
Highly annoyed persons in 40 Lnight Contour	-	0,0%	€ 0	€ 0	€ 0
T5: M10 - reduce 2nd rwy use, M7b evening + morning 7h					
Houses in 58 dB Lden Contour	-388	-5,5%	-€ 100.984	-€ 228.513	-€ 262.790
Houses in 48 dB Lnight Contour	-417	-7,3%	-€ 93.961	-€ 212.622	-€ 244.515
Highly annoyed persons in 48 Lden Contour	-8.771	-7,7%	-€ 4.467	-€ 10.109	-€ 11.626
Highly annoyed persons in 40 Lnight Contour	-1.373	-5,6%	-€ 28.545	-€ 64.594	-€ 74.283
T6: M10 - reduce 2nd rwy use, M7b evening + morning 7h, M8 - 09/27 chance method					
Houses in 58 dB Lden Contour	-2.040	-28,8%	-€ 43.557	-€ 99.212	-€ 114.094
Houses in 48 dB Lnight Contour	-595	-10,5%	-€ 149.338	-€ 340.156	-€ 391.179
Highly annoyed persons in 48 Lden Contour	-13.338	-11,7%	-€ 6.662	-€ 15.174	-€ 17.451
Highly annoyed persons in 40 Lnight Contour	-2.219	-9,1%	-€ 40.049	-€ 91.223	-€ 104.907
T7: M10 - reduce 2nd rwy use, M7b evening + morning 7h, M8 - 09/27 chance method, M1 – Stimulate airlines to use quieter a/c					
Houses in 58 dB Lden Contour	-2.259	-31,9%	-€ 58.069	-€ 116.525	-€ 133.945
Houses in 48 dB Lnight Contour	-648	-11,4%	-€ 202.433	-€ 406.219	-€ 466.946
Highly annoyed persons in 48 Lden Contour	-17.251	-15,2%	-€ 7.604	-€ 15.259	-€ 17.540
Highly annoyed persons in 40 Lnight Contour	-2.317	-9,5%	-€ 56.607	-€ 113.592	-€ 130.573
Combination B: M10 - reduce 2nd rwy use, M7b evening + morning 7h, M8 - 09/27 chance method, M1 – Stimulate airlines to use quieter a/c, M14 - 440k/29k					
Houses in 58 dB Lden Contour	-3.502	-49,5%	-€ 99.814	-€ 314.292	-€ 333.454
Houses in 48 dB Lnight Contour	-1.459	-25,7%	-€ 239.581	-€ 754.388	-€ 800.381
Highly annoyed persons in 48 Lden Contour	-33.946	-29,8%	-€ 10.297	-€ 32.424	-€ 34.401
Highly annoyed persons in 40 Lnight Contour	-4.531	-18,6%	-€ 77.150	-€ 242.928	-€ 257.739
Combination C: M10 - reduce 2nd rwy use, M7b evening + morning 7h, M8 - 09/27 chance method, M1 – Stimulate airlines to use quieter a/c, M15 - 500k/25k					
Houses in 58 dB Lden Contour	-3.007	-42,5%	-€ 61.377	-€ 126.248	-€ 145.141
Houses in 48 dB Lnight Contour	-3.229	-56,8%	-€ 57.157	-€ 117.568	-€ 135.162
Highly annoyed persons in 48 Lden Contour	-24.040	-21,1%	-€ 7.677	-€ 15.791	-€ 18.154
Highly annoyed persons in 40 Lnight Contour	-8.234	-33,8%	-€ 22.415	-€ 46.106	-€ 53.005
		= Noise abatement objective not achieved			
		= Noise abatement objective achieved			

Combination D and E – total costs

- Combinations D and E only use operational procedures coming from pillar 3. This will lead to less congestion and travel/waiting time for airline and passenger/freight respectively.
- In combination D there is also more availability of using quieter aircraf at Schiphol because of the capacity constraint in M14 440k/29k. The cost of the M1 measure is therefore less pronounced coming from T10 to Combination D. However, the lion share of operational costs for airlines are because of idle aircraft and less efficient operation in the M14 440k scenario.
- Combination E has the lowest total costs of all combinations

	M7 M7b evening + morning 7h	**T10** M7b (evening + morning 7h), M1 – Stimulate airlines to use quieter a/c	**COMB - D** M7b evening + morning 7h M1 – Stimulate airlines to use quieter a/c M14 - 440k/29k	**M7** M7a evening only	**COMBI - E** M7a evening only M15 - 500k/27k
Net costs					
Operational costs airlines	-€ 34,5	-€ 76,8 +/- PM	-€ 301,1 +/- PM	-€ 24,3	-€ 44,9
Generalised travel cost passengers/freight	-€ 44,2	-€ 62,1 +/- PM	-€ 674,5 – PM	-€ 31,9	-€ 48,7
Government costs	€ 0,0	-€ 0,9	-€ 15,3	€ 0,0	€ 0,0
Airport Authorities			- PM		
Direct costs	**-€ 78,7**	**-€ 139,8 +/- PM**	**-€ 990,9 -PM**	**-€ 56,2**	**-€ 93,6**
Net External effects (less flights)					
Climate effects - CO2 and non CO2			€ 90,9		
Air quality - NoX			€ 4,3		
Air quality - PM10			€ 0,4		
Additional economic impact Schiphol (agglomeration)	-€ 11,8	-€ 20,8 +/- PM	-€ 146,3 +/- PM	-€ 8,4	-€ 14,0
Total costs (including indirect and external costs):	**-€ 90,5**	**-€** 160,7 +/- PM	**-€ 1.041,5 - PM**	**-€ 64,6**	**-€ 107,7**

Direct and indrect economic impact (gross and net effect) Combination D

	Gross effect (direct+indirect)	Net effect (short-term friction)
Employed Persons	-14.524	-726
FTE	-11.896	-595
Value added (mln. euro's)	-€ 1.358,7	-€ 67,9

Combination D and E – cost effectiveness

- In combination D three out of four noise abatement objectives are met. The fourth noise objective, reduction of annoyed persons in 40 dB Lnight contour is very close (0,1%) of being met.
- However, the cost-effectiveness is relatively low in combination D.
- In combination E, the Lnight objectives are being met, but the M15 objective 500k/27k already achieves both night goals as a measure on its own.

With respect to baseline 500k:	Change in number of houses/persons:	Change in % of houses/persons:	*Net operational costs per reduction of:*	*Direct costs per reduction of:*	*Total costs per reduction of:*
M7b evening + morning 7h					
Houses in 58 dB Lden Contour	-228	-3,2%	-€ 151.265	-€ 344.999	-€ 396.749
Houses in 48 dB Lnight Contour	-421	-7,4%	-€ 81.920	-€ 186.841	-€ 214.867
Highly annoyed persons in 48 Lden Contour	-5.812	-5,1%	-€ 5.934	-€ 13.534	-€ 15.564
Highly annoyed persons in 40 Lnight Contour	-1.373	-5,6%	-€ 25.118	-€ 57.288	-€ 65.881
T10: M7b (evening + morning 7h), M1 – Stimulate airlines to use quieter a/c					
Houses in 58 dB Lden Contour	-472	-6,7%	-€ 162.740	-€ 296.231	-€ 340.384
Houses in 48 dB Lnight Contour	-510	-9,0%	-€ 150.614	-€ 274.159	-€ 315.022
Highly annoyed persons in 48 Lden Contour	-9.378	-8,2%	-€ 8.191	-€ 14.909	-€ 17.132
Highly annoyed persons in 40 Lnight Contour	-1.497	-6,1%	-€ 51.297	-€ 93.374	-€ 107.291
Combination D: M7 evening + morning 7h, M1 – Stimulate airlines to use quieter a/c, M14 - 440k/29k					
Houses in 58 dB Lden Contour	-1.445	-20,4%	-€ 208.343	-€ 685.738	-€ 720.783
Houses in 48 dB Lnight Contour	-1.248	-22,0%	-€ 241.230	-€ 793.984	-€ 834.561
Highly annoyed persons in 48 Lden Contour	-27.483	-24,1%	-€ 10.954	-€ 36.055	-€ 37.898
Highly annoyed persons in 40 Lnight Contour	-3.632	-14,9%	-€ 82.899	-€ 272.855	-€ 286.799
M7a evening					
Houses in 58 dB Lden Contour	-100	-1,4%	-€ 242.588	-€ 561.898	-€ 646.183
Houses in 48 dB Lnight Contour	-	0,0%			
Highly annoyed persons in 48 Lden Contour	-3.378	-3,0%	-€ 7.181	-€ 16.633	-€ 19.127
Highly annoyed persons in 40 Lnight Contour	-0	0,0%			
Combination E: M7a evening only, M15 - 500k/27k					
Houses in 58 dB Lden Contour	-569	-8,0%	-€ 78.982	-€ 164.534	-€ 189.214
Houses in 48 dB Lnight Contour	-1.613	-28,4%	-€ 27.862	-€ 58.041	-€ 66.747
Highly annoyed persons in 48 Lden Contour	-10.486	-9,2%	-€ 4.286	-€ 8.928	-€ 10.267
Highly annoyed persons in 40 Lnight Contour	-5.167	-21,2%	-€ 8.697	-€ 18.117	-€ 20.835

= Noise abatement objective not achieved

= Noise abatement objective achieved

Overview of results Combination A to E

- Total costs are highest in Combination B And D and lowest in Combination E. Combinations A and C are somewhat similar, with a higher restriction in the night (25k) abd associated costs.

Cost effectiveness (next slide):

- Combination B, C and (almost) D achieve the four noise abatement objectives. Combination C is by far the most cost-effective of the three, see next slide.
- Combination E is the most cost-effective in the Lnight 48 and 40 dB Contour.
- Combination A is the most cost-effective in the 58 Lden contour, mainly because of implementing M8 closure of the Buitenveldertbaan.
- Combination E is also the most cost-effective in 48 Lden contour but does not achieve the noise abatement goal.

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

	COMBI A M10 - reduce 2nd rwy use M15 - 500k/29k M7b evening + morning 7h M8 - 09/27 chance method M1 – Stimulate airlines to use quieter a/c	COMBI B M10 - reduce 2nd rwy use M7b evening + morning 7h M8 - 09/27 chance method M1 – Stimulate airlines to use quieter a/c M14 - 440k/29k	COMBI C M10 - reduce 2nd rwy use M7b evening + morning 7h M8 - 09/27 chance method M1 – Stimulate airlines to use quieter a/c M15 - 500k/25k	COMBI D M7b evening + morning 7h M1 – Stimulate airlines to use quieter a/c M14 - 440k/29k	COMBI E M7a evening only M15 - 500k/27k
Net costs					
Operational costs airlines	-€ 144,1 +/- PM	-€ 349,5 +/- PM	-€ 184,6 +/- PM	-€ 301,1 +/- PM	-€ 44,9
Generalised travel cost passengers/freight	-€ 137,7 +/- PM	-€ 735,8 – PM	-€ 194,2 +/- PM	-€ 674,5 – PM	-€ 48,7
Government costs	-€ 0,9	-€ 15,3	-€ 0,9	-€ 15,3	€ 0,0
Airport Authorities		- PM		- PM	
Direct costs	**-€ 282,7 +/- PM**	**-€ 1.100,7 - PM**	**-€ 379,6 +/- PM**	**-€ 990,9 -PM**	**-€ 93,6**
Net External effects (less flights)					
Climate effects - CO2 and non CO2		€ 90,9		€ 90,9	
Air quality - NoX		€ 4,3		€ 4,3	
Air quality - PM10		€ 0,4		€ 0,4	
Additional economic impact Schiphol (agglomeration)	-€ 42,3 +/- PM	-€ 162,8 +/-PM	-€ 56,8 +/- PM	-€ 146,3 +/- PM	-€ 14,0
Total costs (including indirect and external costs):	**-€ 325,0 +/- PM**	**-€ 1.167,8 - PM**	**-€ 436,4 +/- PM**	**-€ 1.041,5 - PM**	**-€ 107,7**

Direct and indrect economic impact (gross and net effect)

	Combination A		Combination B		Combination C		Combination D		Combination E	
	Gross effect (direct+indirect)	Net effect (short-term friction)	Gross effect (direct+indirect)	Net effect (short-term friction)	Gross effect (direct+indirect)	Net effect (short-term friction)	Gross effect (direct+indirect)	Net effect (short-term friction)	Gross effect (direct+indirect)	Net effect (short-term friction)
Employed Persons	-840	-42	-14.524	-726	-840	-42	-14.524	-726	-	-
FTE	-700	-35	-11.896	-595	-700	-35	-11.896	-595	-	-
Value added (mln. euro's)	-€ 76,2	-€ 3,8	-€ 1.358,7	-€ 67,9	-€ 76,2	-€ 3,8	-€ 1.358,7	-€ 67,9	-	-

Overview of results Combination A to E

Costs in euro's with respect to baseline (500k)

	COMBI A M10 - reduce 2nd rwy use M15 - 500k/29k M7b evening + morning 7h M8 - 09/27 chance method M1 – Stimulate airlines to use quieter a/c	COMBI B M10 - reduce 2nd rwy use M7b evening + morning 7h M8 - 09/27 chance method M1 – Stimulate airlines to use quieter a/c M14 - 440k/29k	COMBI C M10 - reduce 2nd rwy use M7b evening + morning 7h M8 - 09/27 chance method M1 – Stimulate airlines to use quieter a/c M15 - 500k/25k	COMBI D M7b evening + morning 7h M1 – Stimulate airlines to use quieter a/c M14 - 440k/29k	COMBI E M7a evening only M15 - 500k/27k
Net operational costs *per reduction of (wrt baseline 500k in euro's):*					
Houses in 58 dB Lden Contour	-57.381	-99.814	-61.377	-208.343	-78.982
Houses in 48 dB Lnight Contour	-98.795	-239.581	-57.157	-241.230	-27.862
Highly annoyed persons in 48 Lden Contour	-7.195	-10.297	-7.677	-10.954	-4.286
Highly annoyed persons in 40 Lnight Contour	-31.814	-77.150	-22.415	-82.899	-8.697
Net total costs *per reduction of (wrt baseline 500k in euro's) :*					
Houses in 58 dB Lden Contour	-112.549	-314.292	-126.248	-685.738	-164.534
Houses in 48 dB Lnight Contour	-193.779	-754.388	-117.568	-793.984	-58.041
Highly annoyed persons in 48 Lden Contour	-14.112	-32.424	-15.791	-36.055	-8.928
Highly annoyed persons in 40 Lnight Contour	-62.401	-242.928	-46.106	-272.855	-18.117
Total societal costs *per reduction of (wrt baseline 500k) :*					
Houses in 58 dB Lden Contour	-129.379	-333.454	-145.141	-720.783	-189.214
Houses in 48 dB Lnight Contour	-222.755	-800.381	-135.162	-834.561	-66.747
Highly annoyed persons in 48 Lden Contour	-16.222	-34.401	-18.154	-37.898	-10.267
Highly annoyed persons in 40 Lnight Contour	-71.731	-257.739	-53.005	-286.799	-20.835

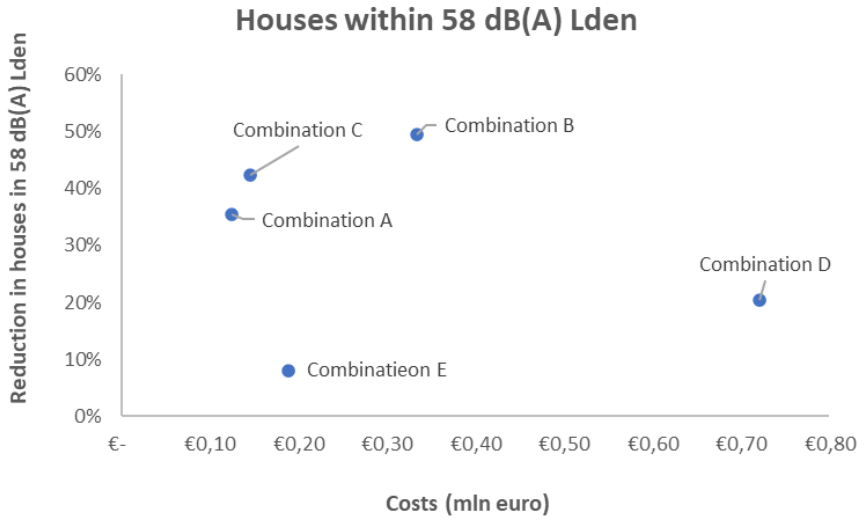
= Noise abatement objective not achieved

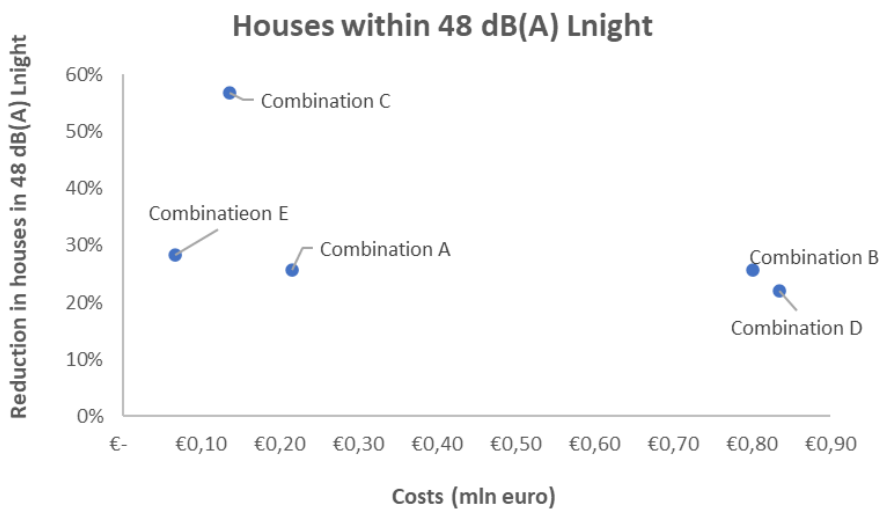
= Noise abatement objective achieved

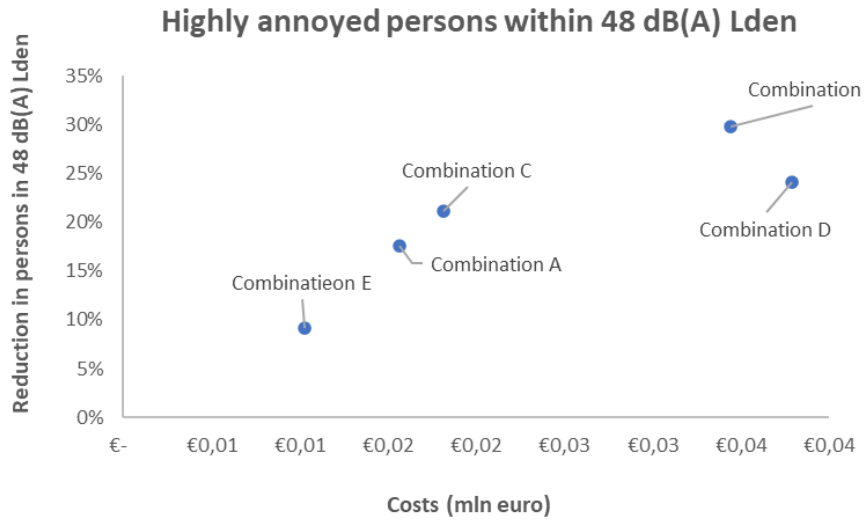
Overview of results Combination A to E

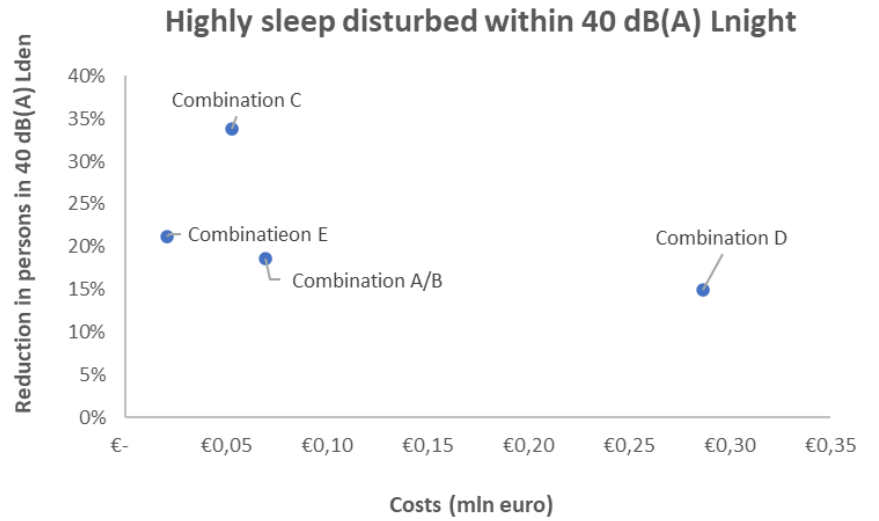
Horizontal axis: Total costs to society per reduction of house or person within dB (a) contour in mln. of euros.

Vertical axis: Percentage reduction of houses or persons with dB (a) contour.









Higher noise reduction potential

Less cost effective

Overview of results Combination A to E

Overall conclusions

Combination C achieves all noise objectives against the lowest total costs. It consists of:

- Reducing the use of secondary runways
- Extending the night regime in the evening and early morning
- Closure of the Buitenveldertbaan
- Stimulating airlines to use quieter aircraft and
- Reducing the number of night flights to 25k per year

The total costs amount to over 400 million euro's per year

The impacts on gross employment and value added are limited. The net impacts are even smaller and in the longer-term close to zero

Combination C significantly overshoots various noise objectives. Finetuning the combination may further reduce costs and still achieve all four noise objectives

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Appendices

Appendix A. key figures – operational costs

Operational costs per block hour airlines:

The operating costs per block hour depend on the size of the aircraft, the age of the aircraft, type of airline (network carrier or low-cost/charter) and region of the world (due to differences in wages / social premiums etc). For estimating the impacts of longer flight times at Schiphol we use operating costs that best resemble the local situation.

For KLM the operating costs per block hour were estimated based on their annual reports. For European network carriers we use the same values as their cost structure likely resembles that of KLM. For non-European network carriers the operational costs per block hour for US carriers are used (as published by the FAA). Cargo flights are often operated by non-European carriers. Therefore, we also use the FAA values for cargo carriers. For low-cost carriers and charters we use the operating costs per block hour for easyJet. Some ultra low-cost carriers as Ryanair and Wizz Air may operate at even lower costs, but others might have higher costs. This results in the following (right table in prices 2018):

- KLM & European network carriers: use the estimated values per aircraft category for KLM;
- Non-European network carriers: use the values estimated by the FAA;
- Cargo flights: use the values estimated by the FAA, except for KLM;
- Low-cost carriers & charters: use the easyJet values for 2018.

Prices 2018 euro's and total with CPI correction 2022

Airline category	Variable costs				Fixed costs					Total	
	Fuel	Maintenance	Crew	*Subtotal*	Depreciation	Rentals	Insurance	Other	*Subtotal*	Prices (2018)	CPI correction (2022)
KLM & European network carriers											
Wide-body more than 300 seats	6.406	2.080	3.098	*11.583*	1.215	316	33	-	*1.564*	**13.147**	**-15.433**
Wide-body 300 seats and below	4.830	2.014	2.442	*9.286*	985	285	33	-	*1.303*	**10.588**	**-12.429**
Narrow-body more than 160 seats	2.432	1.122	1.515	*5.068*	510	169	25	-	*704*	**5.772**	**-6.776**
Narrow-body 160 seats and below	2.061	1.152	1.360	*4.572*	440	167	41	-	*648*	**5.221**	**-6.129**
RJ more than 60 seats	136	673	584	*1.393*	188	196	8	-	*393*	**1.786**	**-2.097**
Non-European network carriers											
Wide-body more than 300 seats	4.582	1.127	1.995	*7.703*	715	344	3	1	*1.062*	**8.765**	**-10.289**
Wide-body 300 seats and below	3.455	1.091	1.572	*6.119*	580	310	3	3	*896*	**7.015**	**-8.235**
Narrow-body more than 160 seats	1.739	608	975	*3.323*	301	184	3	6	*493*	**3.815**	**-4.478**
Narrow-body 160 seats and below	1.474	624	876	*2.974*	259	182	4	6	*451*	**3.425**	**-4.021**
Cargo flights											
Four-engine wide-body (KLM)	6.693	3.667	2.639	*12.999*	976	2.668	197	-	*3.842*	**16.841**	**-19.770**
Four-engine wide-body (other)	4.787	1.987	1.699	*8.473*	575	2.903	20	19	*3.517*	**11.992**	**-14.078**
Three-engine wide-body	4.134	4.025	1.949	*10.108*	964	216	18	174	*1.371*	**11.478**	**-13.474**
Two-engine wide-body	2.570	1.682	1.782	*6.033*	719	379	24	111	*1.233*	**7.266**	**-8.530**
Narrow-body more than 160 seats	1.981	2.412	1.879	*6.272*	1.183	150	26	93	*1.451*	**7.723**	**-9.066**
Narrow-body 160 seats and below	1.119	479	1.327	*2.925*	244	-	39	147	*430*	**3.356**	**-3.940**
Low-cost carriers & charters											
Narrow-body	1.230	325	699	*2.255*	207	158			*365*	**2.619**	**-3.074**

Appendix A. key figures – Aircraft utlization and VOT

Aircraft utilization costs:

Measures that limit airport opening hours may reduce the number of flights an aircraft can make. This means that aircraft utilization is affected, and airlines need more aircraft to operate the same amount of flights. This leads to higher fixed costs. When aircraft utilization (block hours per aircraft) decreases by x percent, the number of aircraft required increases by 1/(1-x%)-1 percent. Its fixed operating costs increase by the same percentage.

Box. Illustration

Suppose an airline operates 40 return flights per day, each requiring 2.5 block hours. This amounts to 100 block hours per day. It has a fleet of 10 aircraft which each operate 4 return flights per day requiring 10 block hours. Due to limited opening times at an airport, its aircraft utilization reduces from 4 to 3 return flights per day and each aircraft only operates for 7.5 hours per day (-25%). This means that with its fleet of 10 aircraft it can only operate 75 block hours per day. To operate its full schedule with 100 block hours it needs 1/(1-25%)-1 = 33% or 3.3 additional aircraft.

We can use the fixed operating cost per block hour in the table of the previous slide to estimate the additional costs as a result of reduced aircraft utilization. So, when the average number of block hours decrease by x percent, the fixed costs in table 7 increase by 1/(1-x%)-1 percent.

Time travel costs (VOT) passengers and freight

The generalized time travel costs are based on the value of time studies coming from the Dutch Kennisinstuut voor Mobiliteitsstudies (KiM) in 2013 (De maatschappelijke waarde van betrouwebare reistijden, KiM 2013). In these studies value of time (VOT) per hour are derived from stated preference surveys conducted among business and non-business travellers.

Travel Motive air passenger	VOT per hour (2010)	VOT per hour (2022)**
Business	€ 86	€ 122
Non-business (leisure, VFR)	€ 47	€ 67
Average*	**€ 52**	**€ 74**

** Weights are based on the distribution of motives in traveled minutes from the stated preference survey of KiM (Business: 12,3%; Non-Business: 87,7%)*

*** CPI of 2022 and 50% of growth of real wage rate*

Freight	VOT per hour (2010)	VOT per hour (2022)*
Average per flight	€ 14.900	€ 19.754

** CPI of 2022 and 25% growth of real wage rate*

Appendix A. key figures – economic impact and agglomeration effects

Economic impact Schiphol

Calculation of the economic impact of measures are based on the economic impact studies of Decisio in 2018 considering an update of the total economic impact of Schiphol and the economic impact of the air cargo and freight sector at Schiphol.

In these studies a thorough analysis of the amount of people employed directly at Schiphol and outside Schiphol including the value added was conducted. In addition also the indirect economic impacts were assessed with the backward linkages of the supplying sectors to the aviation industry currently active at Schiphol.

The amount of employed persons are used to calculate the government costs of unemployment allowances (approx. 17.000 euro's per employed person) yearly and decrease in tax revenues (approx. 5.000 euro's per FTE) because of frictional unemployment of 5 percent the total number of employed persons decreases in the short-term.

Total economic impact Schiphol (2018)

	Employed persons Number	FTE Number	Valued added in mln. €	Valued added (2021) in mln. €
Direct at Schiphol	58.078	48.114	€ 6.216	€ 6.392
Direct outside Schiphol	10.348	8.860	€ 1.085	€ 1.115
Indirect backwards outside Schiphol	45.485	36.226	€ 3.081	€ 3.168
Total	**113.912**	**93.200**	**€ 10.382**	**€ 10.676**

Source: Update Economic Impact Study of Schiphol Airport, Decisio 2018

Economic impact air cargo/freight Schiphol (2018)

	Employed persons	FTE	Valued added	Valued added (2021)
Direct	**16.000**	**14.200**	**€ 1.840**	**€ 1.892**
Air freight at Schiphol	11.700	10.400	€ 1.360	€ 1.398
Air freight outside Schiphol	4.300	3.800	€ 480	€ 494
Indirect backwards	**14.600**	**11.200**	**€ 880**	**€ 905**
Inside Greater Amsterdam Area	10.400	7.800	€ 610	€ 627
Rest of the Netherlands	4.200	3.400	€ 270	€ 278
Totaal (direct + indirect)	**30.600**	**25.400**	**€ 2.720**	**€ 2.797**

Source: Economic impact of Air Freight at Schiphol Airport, Decisio 2018

Additional agglomeration effects

The direct impacts on connectivity, accesibility and travelling costs for passengers, freight and airlines have impacts on the attractivity of the Schiphol area as a business location and in terms of productivity, knowledge spillovers and innovation. These additional agglomeration effects are estimated by Elhorst et. al (2004) between zero to thirty percent of the direct effects on connectivity and (generalized) travel costs. In this study we use the mean value of fifteen percent.

Appendix A. key figures – external effects

External effects are the effects caused by the aviation industry that impact climate change and the living environment (f.i. air quality, noise pollution, external safety, nature). In this study we quantify the effects of climate change and air quality when a meaure reduces flights on a global level. The effects of noise pollution are already assessed in the cost effectiveness per reduction of annoyed household and persons.

Climate effects

CO_2 emissions of aircraft contribute to climate change on a global level. When the number of flights stays the same we do not assume a change in CO_2 emissions with respect to the baseline scenario. However, there may be small impacts due to the use of different runways. These changes fall in the so-called margin of error.

When the total number of flights changes there will be an impact on CO2 emissions. This is only the case in the 440k scenario. Some passengers that cannot be accomodated at Schiphol deviate to other airports, which will increase the number of flights at those airports. For a correct calculation of the global CO2 impacts it is therefore relevant to estimate the number of passengers that no longer use air transport. The reduction in total passenger demand is estimated based on price elasticities summarized in various studies (PriceWaterhouseCoopers, 2005; Intervistas, 2007; Morlotti et al., 2017). According to the segmentation (full service carriers and low-cost carriers) and destination per region we estimate passenger reduction leads to a decline in of 37.000 (of 60.000 total) flight movements

To calculate the reduction in fuel consumption and CO_2 emissions of these flights we use the ICAO Eurocontrol emission calculator (Version 5.11 7 december 2021). In this tool we can differentiate between aircraft type and distance to destination flown. This leads to approximately 154.000 tons reduction of fuel consumption which corresponds to a reduction of around 484.000 tons of CO_2 emissions on a yearly basis in 2024. To estimate the effect in euro's we use the CO_2 effective price (used in the models and scenario's build by Central Planning Bureau) in 2024 of 94 euro per tonne.

Next to CO_2 emissions also other substances have an impact on climate change such as nitrogen oxides, water vapor, sulphur dioxide and soot (Werkwijzer luchtvaartspecifieke MKBA's, SEO, Decisio, 2021). The climate effects of these non CO_2 components are not easy to determine as they depend on different factors like flight altitude, location, timing and atmospheric composition. Therefore, to estimate these non CO_2-emissions we use a factor of 1 on the estimated CO_2-effect recommended in the guidline of aviation SCBA's (SEO, Decisio, 2021).

Air quality

To estimate the net effects on air quality we look at the emissions of nitrogen oxide (NO_x) and particle matter (PM_{10}) in the LTO-cycle of the reduction of 37.000 flights on a global scale. See table below for the key figures and prices.

	Narrowbody	Widebody	Price per kg
NOx KG per cycle	4,0	7,5	€ 50,2
PM10 kg per cycle	0,3	0,3	€ 65,1

Source: ICAO Aircraft engine Emissions Databank, Feb 2023 and emission prices WLO-Hoog, PBL/CPB

Appendix B. M1 - Differentiation of airport charges

Determining possibilities for differentiation of airport charges:

To determine how much the airport charges at Schiphol can be further differentiated, we link the charges to the movements at Schiphol in 2019 based on: whether the flight taking-off or landing; whether it is a cargo or passenger flight; whether it is during the day or nighttime and how the aircraft is categorized (category S1-S7). By multiplying the rate by the aircraft weight for all flights, you get the total amount of differentiated airport charges*. We are lowering the charges in category S2-S7 with the lowest possible fare for both cargo and passenger flights. Lowering some rates further may lower the incentive towards S7 or towards the day.

For example, if you lower the charges of S3 further than this in order to be able to increase the charges of S1 further, that reduces the incentive to move from S3 to an even quieter category. The charges in category S1 can increase by the total reduction of the airport charges for flights in the higher categories. This way, the differentiated part of the airport charges in category S1 will increase by 89%, while the charges in S2-S7 will decrease by an average of 26%.**

* The total amount of differentiated airport charges for S1 up to S7 aircraft landing and take-off charges are upwards of 360 million euros. In reality this total amount will be lower as we used the charges paid for connected stands which are higher than the charges paid for disconnected stands.

** The charges in category S1 were all raised by 89%. Because the charges in categories S2-S7 were lowered by a fixed amount the differences in percentages are larger in the higher categories and lower in the lower categories.

Appendix C. M14 - Deviation costs for passengers

To70 has canceled flights according to the method described earlier. We merged this list of canceled flights with a dataset of Schiphol in 2019 containing the average number of OD travelers on a flight of a specific airline/destination combination*. By multiplying these averages per flight by the number of these types of canceled flights, we arrive at a decrease of more than four and a half million OD passengers. These passengers can divert to other airports. We use six** (larger) airports for this, because it is not realistic that one (nearby) airport can accommodate all diverting passengers. We multiply the average travel time to these airports by the value of time of airline passengers. We apply the rule-of-half to the part of travelers we expect not to divert.

*In cases for which merging was not possible we used the average number of passengers in the flight's segment. This was the case for 89 out of the 480 canceled airline/destination combinations and 330.000 of the 4,6 million OD passengers.

**Brussels, Düsseldorf, Eindhoven, Frankfurt, London (Heathrow) & Paris.