National Institute for Public Health and the Environment
Ministry of Health, Welfare and Sport

Research program health risks ultrafine particles around Schiphol Airport

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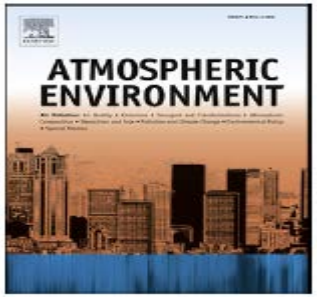
Frankfurt, 23 August 2019



Background

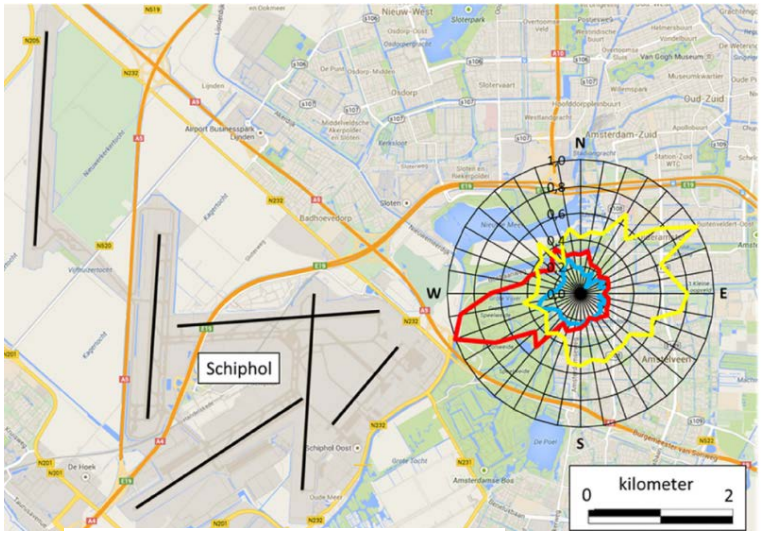
HIGHLIGHTS

- Ultrafine particles are a factor 3 elevated 7 km downwind Schiphol airport.
- The size-distribution of these particles is dominated by particles of 10–20 nm.
- 45,000/60,000 addresses exposed to 5–10,000 (annual)/10–20,000 (hourly) #/cm^3.

TNO study (2014):

Schiphol Airport important source of UFP concentrations in the range of 10-20 nm; finding elevated levels at 7 km distance (Keuken et al. Atm Env, 2015)

- **RIVM exploratory study**



UFP (daytime) UFP (night) BC

RIVM exploratory research

2015:

1. Literature review
2. Measurements of UFP

   - ➢ Confirmation of TNO study
   - ➢ No health studies published in relation to UFP from air traffic

2016:

1. Exploratory study into mortality
2. Advice about the feasibility and design of possible follow-up studies

   - ➢ 5 year research program (2017-2021)

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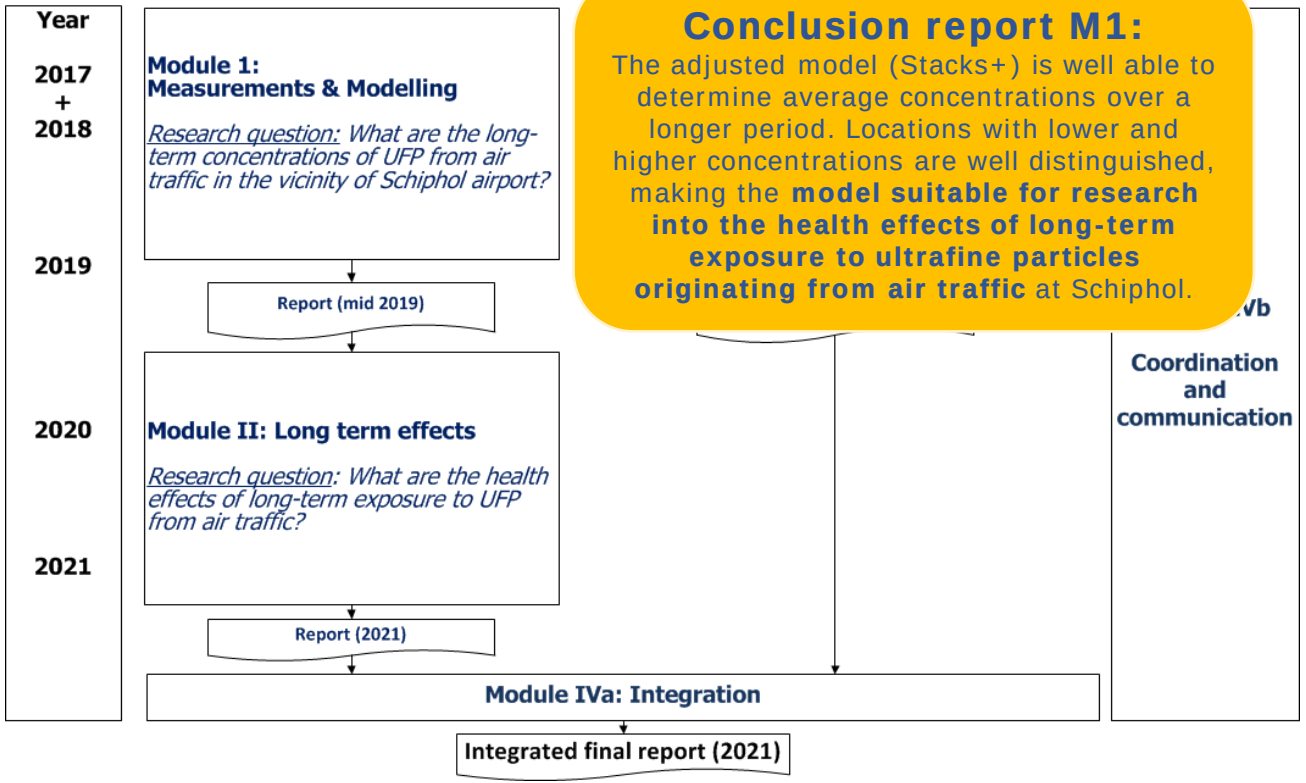
Structure research program

Aim:

To gain understanding into the potential adverse health effects of UFP around Schiphol airport

www.rivm.nl/ultrafijnstofschiphol



Conclusion report M1:
The adjusted model (Stacks+) is well able to determine average concentrations over a longer period. Locations with lower and higher concentrations are well distinguished, making the **model suitable for research into the health effects of long-term exposure to ultrafine particles originating from air traffic** at Schiphol.

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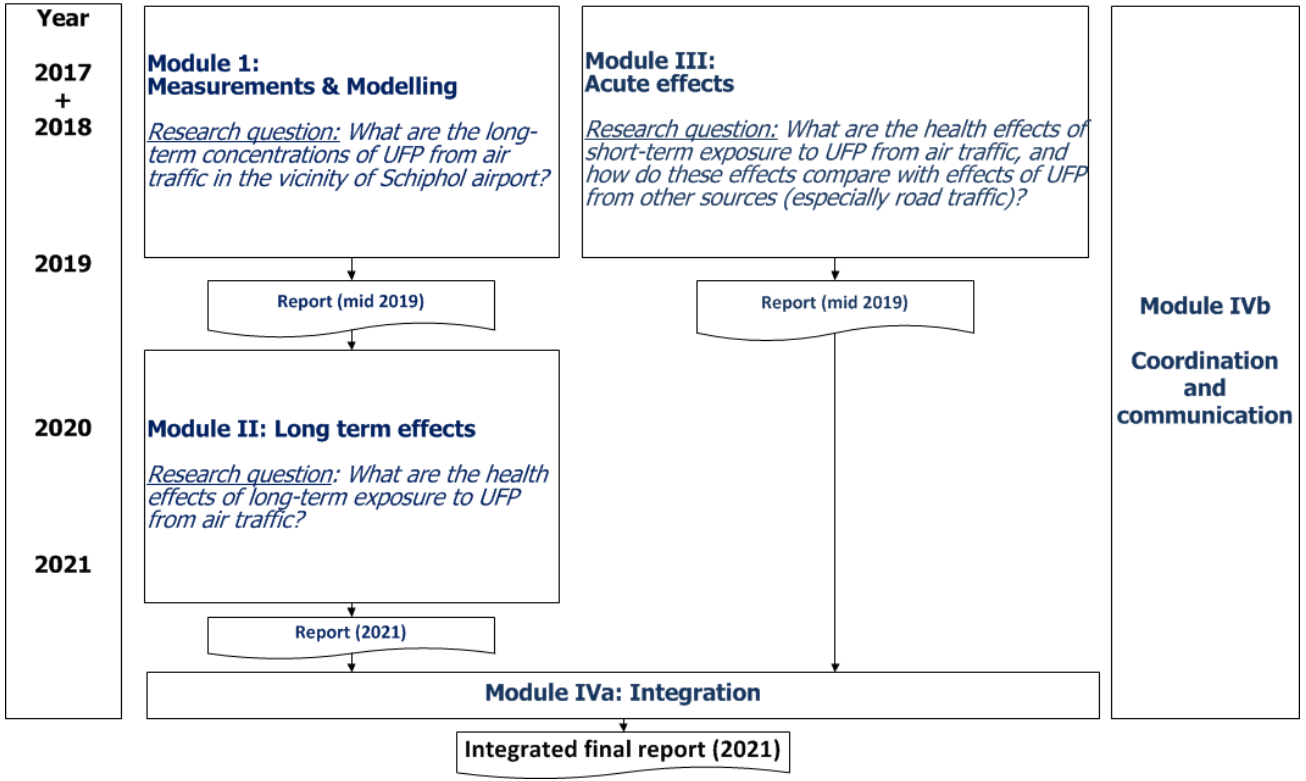


Module III: Effects of short-term exposure

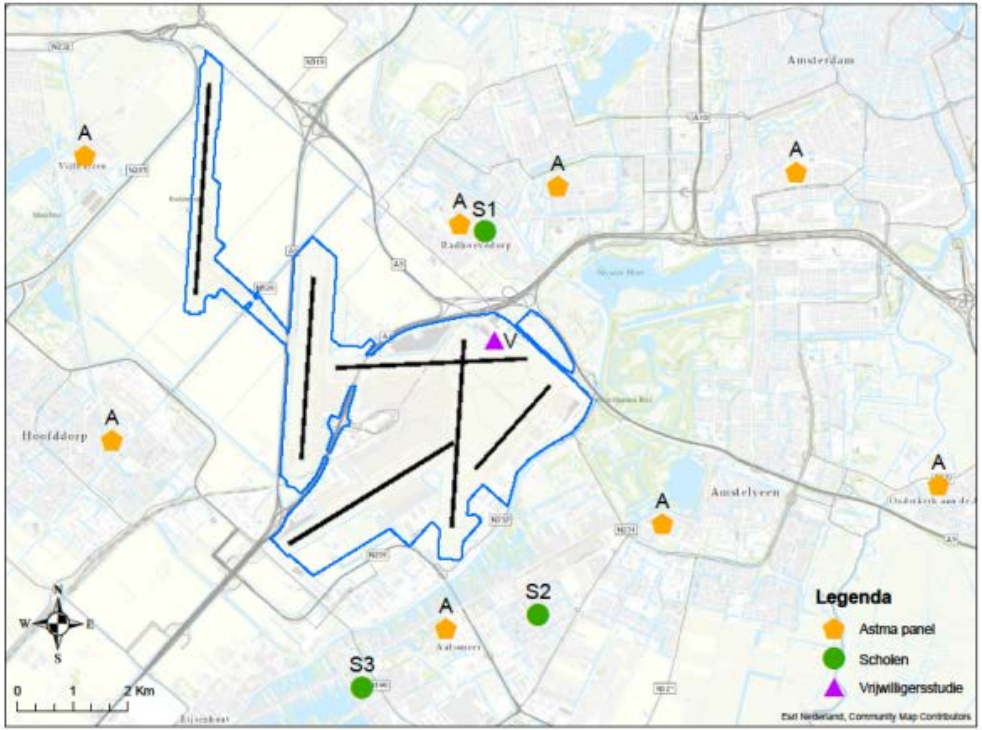
Research questions

1. *What are the health effects of short-term exposure to UFP in general and of UFP from aviation in particular?*
2. *How do these effects compare to effects of UFP from other sources (mainly road traffic)?*

3 studies with varying designs:

1. **Panel study** with primary school children in residential areas near Schiphol (at real-life concentrations))
2. **Volunteer study** with healthy adults directly next to Schiphol (experimental research at high concentrations)
3. **Toxicological study** with lung cells (in-vitro)

Locations



Panel studie

- 161 children from 3 schools situated in Badhoevedorp (S1) and Aalsmeer (S2+S3) (school panel)
- 30 children with asthma from the wider area around Schiphol (asthma panel).

Volunteer study

- 21 young healthy adults exposed in a mobile lab next to the airport (V)

Toxicological study

- Lung cells, exposed to UFP collected at the site of the volunteer study and directly from the exhaust of a turbine engine.

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Overview of the different studies

	Panel study	Volunteer study	Toxicological study
Design	Observational study	Experimental field study	Experimental laboratory study
Population/model	Primary school children - School panel - Asthma panel	Healthy adults	Model for respiratory epithelial cell barrier (Calu-3 cells)
Location of exposure	Living environment	In a mobile lab next to the airport	In the lab to UFP sampled: 1) next to Schiphol at different wind directions; 2) Directly from the exhaust of a jet engine
Exposure metrics	Total and size-specific particle number measured at school. Modelled particle number from aviation at home	Total and size-specific particle number measured on site	Particle mass (dose µg/cm^2) and mean particle size distribution (measured in particle suspensions)
Duration of exposure	Continuous (real-life residential area concentrations)	5 hours (low to high concentrations)	24 hour; 4 different doses
Co-pollutants	BC (measured at school) NO_2, PM2.5 (from national monitoring network)	BC, NO_2, CO, O_3, PM2.5 measured on site	None
Health endpoints - respiratory	All children: Daily spirometry and symptom recording at home School panel: weekly exhaled NO and supervised spirometry at school	Spirometry Exhaled NO	Cytotoxicity (cell viability and cell damage) Pro-inflammation (cytokines IL-6 and IL-8)
Health endpoints - other	No	ECG (including heart rate), Oxygen saturation, Blood pressure, Urine[2]	No

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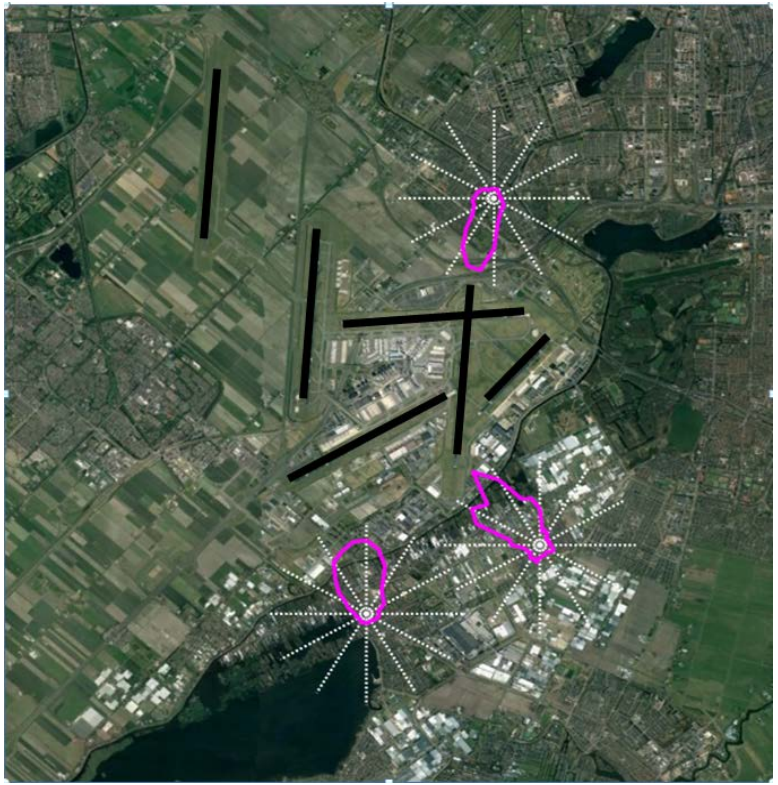
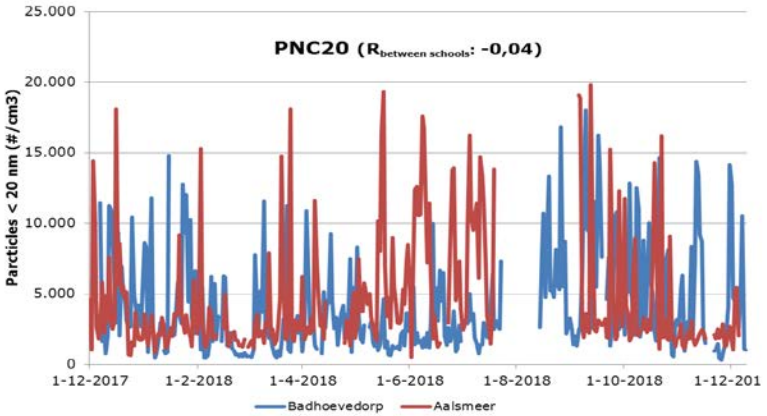
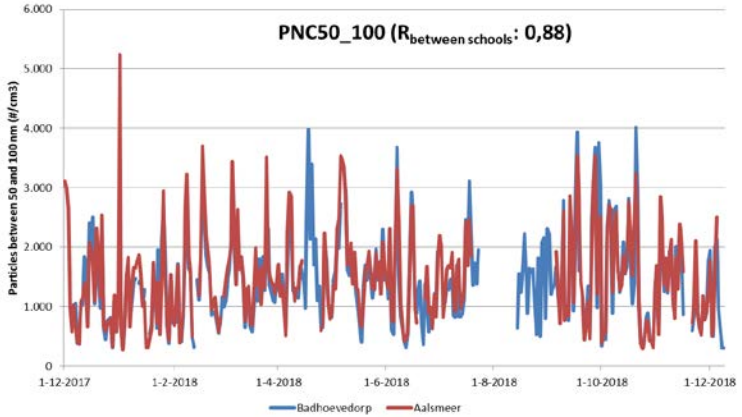
Panel study (schoolyard measurements)







Data analysis panel study

- Investigated whether changes in UFP concentration were associated with changes in respiratory health.
- For UFP of the same day, the previous day, and two days before the health measurement, as well as the average of the 3 days before the measurement.
- For total UFP, for UFP mainly from air traffic (PNC20) and for UFP mainly from road traffic (PNC50_100)
- Expressed as the difference between a health measurement after a period with high UFP and a health measurement after a period with low UFP (p5-p95 increment).

Results panel study

Respiratory symptoms and medication use

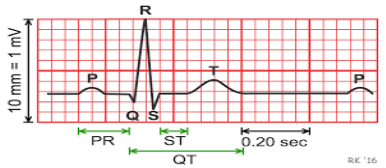
- Significant associations between exposure to UFP and an increase in daily respiratory symptoms and bronchodilator use.
- Both for total UFP, for UFP mainly from aviation and for UFP mainly from road traffic.
- Strongest associations for wheeze and bronchodilator use

Lung function and exhaled NO

- No consistent associations between variations in UFP and weekly lung function measurements at school or daily lung function in the evening (at home)
- Significant association between exposure to UFP from road traffic and reduced lung function in the morning (at home)
- No consistent associations with exhaled NO (indicator for pulmonary inflammation)

Volunteer study

- 21 healthy volunteers exposed for 5 hours in a mobile lab next to the airport
- 2-5 exposure per person; 32 exposure days (total 86 exposures)
  - ➢ Large variation in UFP (10.000-170.000 #/cm^3)
- Measurements of UFP and other air pollutants during the exposure
- Health measurements before and after the exposure (lung function, exhaled NO, ECG, blood pressure, oxygen saturation)



Results volunteer study

- Short-term (5 hour) increased exposure to UFP, as occurs right next to Schiphol, was associated with direct changes:
  - A decline in lung function (FVC)
  - A prolongation of the QTc interval (ECG)

- This applied to both total UFP and UFP mainly from air traffic

- UFP from road traffic was significantly associated with an increase in systolic blood pressure.

- For other lung and cardiac function parameters, exhaled NO and oxygen saturation, no statistically significant associations with UFP were observed

Toxicological study

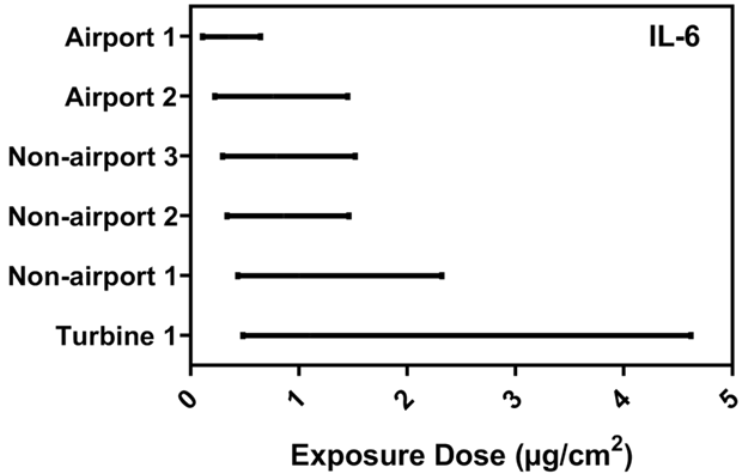
UFP sampling:

- Location volunteer study (5x):
  - Classified as ‘airport’ (2x) and ‘non-airport’ (3) based on wind direction
  - Directly from the exhaust of a turbine engine (2x)
  - Turbine-1: taxiing and idling
  - Turbine-2: full thrust
- Standard reference material for diesel (NIST)

Results toxicological study

Cell damage

Pro-inflammatory markers



- Exposure of lung cells to UFP leads to cell damage and release of pro-inflammatory markers
- No significant differences in reactivity between the different sources of UFP (overlap black lines)

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Summary of the 3 studies

Health parameter	Location	Population/model	Associations for UFP from aviation	Associations for UFP from road traffic
Panel study (children)				
Daily symptoms	At home	Combined school and asthma panel	Yes, especially for wheeze and phlegm	Yes, especially for wheeze and shortness of breath during rest
Bronchodilator use	At home	Combined school and asthma panel	Yes	Yes
Daily lung function	At home	Combined school and asthma panel	No	Yes, in the morning
Lung function, supervised, weekly	School	School panel	No, not consistent over multiple parameters	No, no consistent over multiple parameters
Exhaled NO (weekly)	School	School panel	No, not consistent for children with and without asthma	No, not consistent for children with and without asthma
Volunteer study				
Lung function	Next to Schiphol	Healthy adults	Yes, for FVC	No
Exhaled NO ; oxygen saturation	Next to Schiphol	Healthy adults	No	No
Heart function	Next to Schiphol	Healthy adults	Yes, for QTc	No, not consistent
Blood pressure	Next to Schiphol	Healthy adults	Nee	Ja
Toxicological study			Reactivity	
Cell damage and pro-inflammatory markers	Next to Schiphol and from the source	Lung cells (in vitro)	Yes. No significant differences in reactivity between UFP sampled during difference wind directions (airport vs non-airport) and directly from a turbine engine	

Conclusion

- Together these studies show that short-term increased exposure to UFP, as occurs around Schiphol, is associated with acute health effects.
- This applies to both total UFP (from all sources) and UFP mainly from air traffic
- No indications that effects of UFP from aviation are substantially different from those of UFP from road traffic

Implications

- The increase in daily respiratory symptoms and medication use among children in the vicinity of Schiphol is health-relevant
- Although the observed short-term changes in lung (children & adults) and heart function (adults) are relatively small based on a group average, they may be greater for sensitive individuals.
- It is not yet clear what this means in the long term. This is investigated in Module II of this research program (Research into the effects of long-term exposure to ultrafine particles from aviation)
- Results of Module II are expected in 2021.

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Thank you!