Air quality impact of aviation

An important problem that can be mitigated with higher quality fuel

TRANSPORT & ENVIRONMENT

Aviation emissions

- Aviation: 0.1-0-2% of global PM emissions (Klimont et al., 2017)
- 14% of emissions at/near ground (Landing-Take Off Cycle) - significant emissions source around airports

Emission species	Abbreviation	Emission factor (kg/LTO)
Particulate matter, <10 µm	PM_{10}	0.54
Particulate matter, <2.5 µm	$PM_{2.5}$	0.53
Hydrocarbons	HC	2.68
Nitrogen oxides	NO_x	16.29
Carbon monoxides	CO	9.14
Volatile organic carbons	VOC	1.95
Black carbon	BC	0.26
Sulphur dioxide	SO_2	1.40

Data obtained from (Bo et al., 2019).

Jet fuel quality and air pollution

- Non Volatile Particulate Matter (nvPM)
  - Soot (black carbon + impurities)
  - Incomplete combustion
  - **Driven largely by aromatics**

- Volatile Particulate Matter (vPM)
  - Liquid droplets formed from condensed gas emissions
  - **Driven by sulphur**

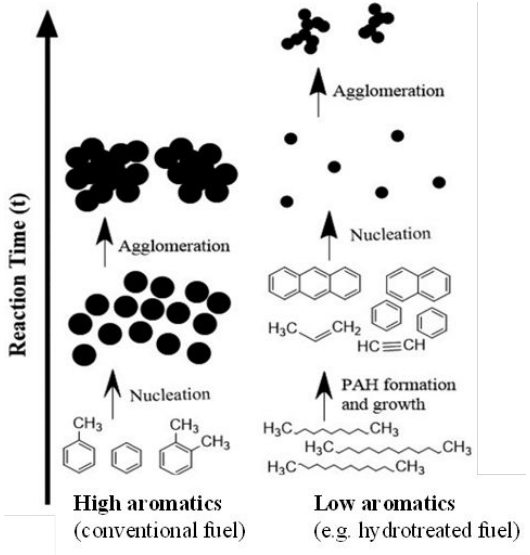


Figure from Kumal et al., 2020, “Impact of Biofuel Blends on Black Carbon Emissions from a Gas Turbine Engine”

Population at risk: around airports…and beyond

A study in 4 European cities (London, Barcelona, Zurich, Helsinki) found that aircraft emitted particles could be found in the city centre of all of them

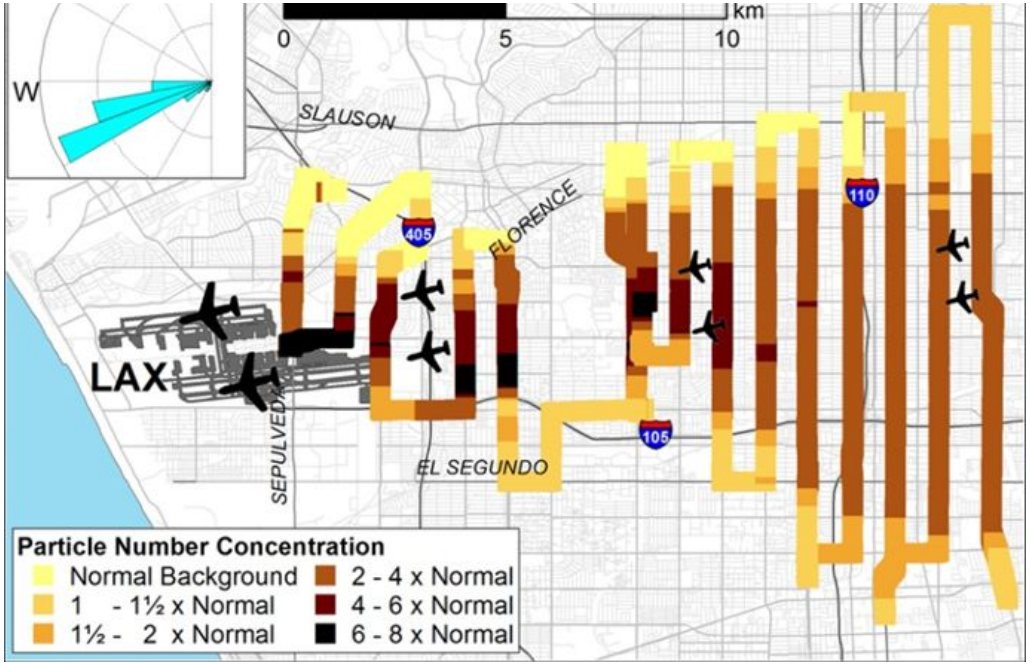


Figure from Hudda et al., 2014, “Emissions from an international airport increase particle number concentrations 4-fold at 10 km downwind”

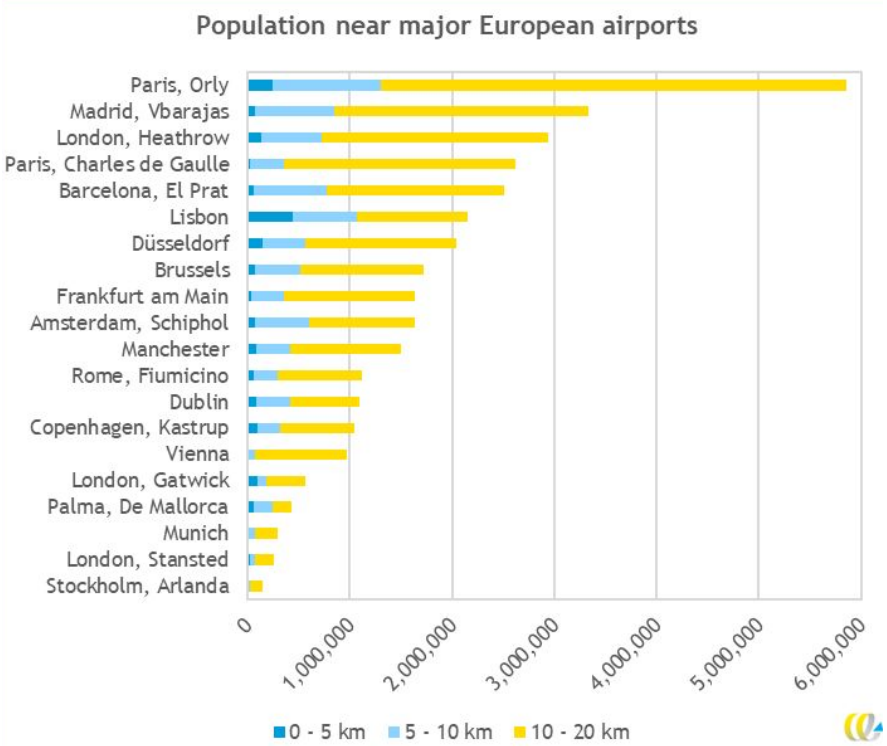
No small problem

33+ million people

live within a 20 km

radius of the top-20

European airports



Source: To70 & CE Delft

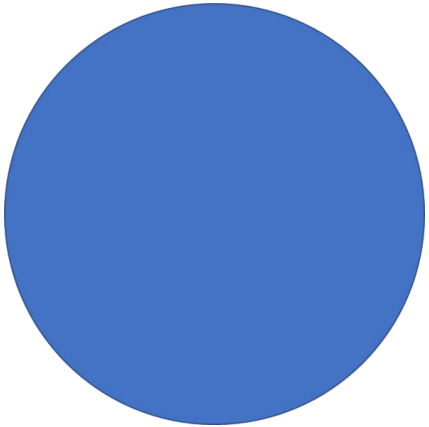
Quantifying the problem (or trying to)

Table 0.1. Recommended AQG levels and interim targets

Pollutant	Averaging time	Interim target				AQG level
		1	2	3	4	
$PM_{2.5}$, µg/m³	Annual	35	25	15	10	5
	24-hour[a]	75	50	37.5	25	15
PM_{10}, µg/m³	Annual	70	50	30	20	15
	24-hour[a]	150	100	75	50	45

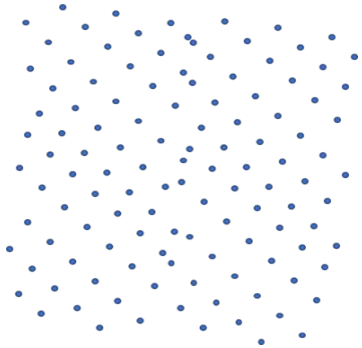
Same mass, same problem?

1 particle of 2.5 micrometers



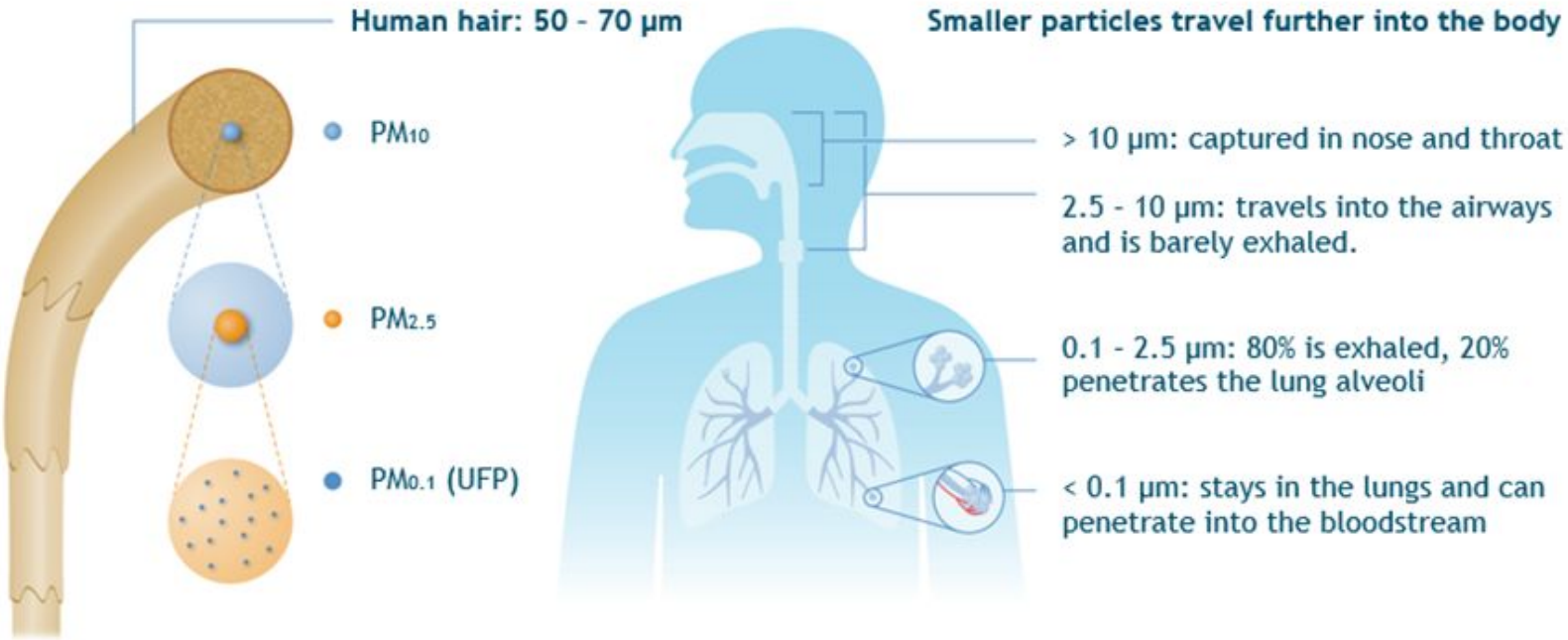
1 million particles of 25 nanometers

100X more surface*



*Assuming same composition and spherical shape

Ultra Fine Particles (UFPs): deeper for longer



Adapted from Gezondheidsraad, 2018, “Gezondheidswinst door schonere luch”. All rights belong to Joris Fiselier infographics.

How are people affected?

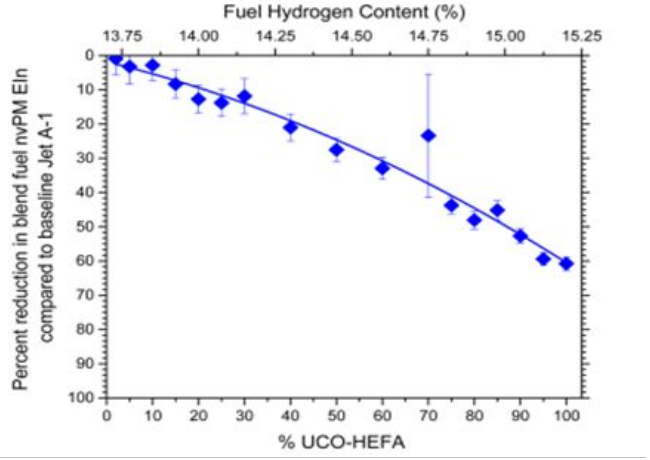
Correlation with increased risk of

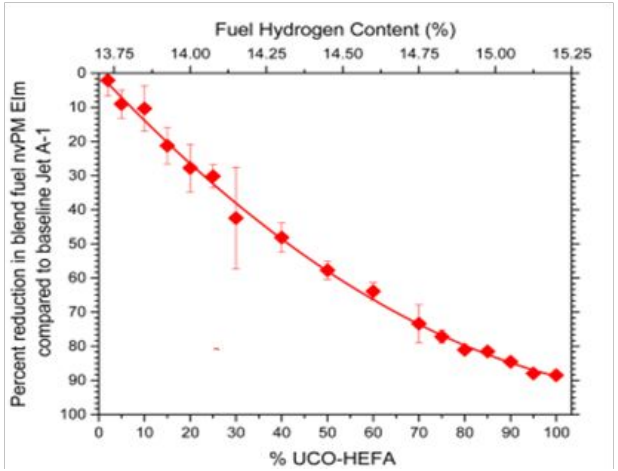
- High blood pressure (clear)
- Heart attack (clear)
- Diabetes (clear)
- Birth defects (likely)

Black carbon is the main driver of health impact

Hydrotreated fuels as a solution

- Reduction in sulphur → **Fewer vPM emissions**
- Reduction in naphthalene and mono-aromatics → **Fewer nvPM (soot/black carbon) emissions**





Figures from Lobo et al., 2015, “Evaluation of Non-volatile Particulate Matter Emission Characteristics of an Aircraft Auxiliary Power Unit with Varying Alternative Jet Fuel Blend Ratios”

Cost quantification of health impact - EASA 2010

€130 - €430 million/year* of healthcare expenditure could be saved by hydrotreating fuels…

*Results may be underestimated, as mass was used as an indicator instead of particle number


EUROPEAN AVIATION SAFETY AGENCY
AGENCE EUROPÉENNE DE LA SÉCURITÉ AÉRIENNE
EUROPÄISCHE AGENTUR FÜR FLUGSICHERHEIT

Research project EASA.2008/C11

Reduction of sulphur limits in aviation fuel standards (SULPHUR)

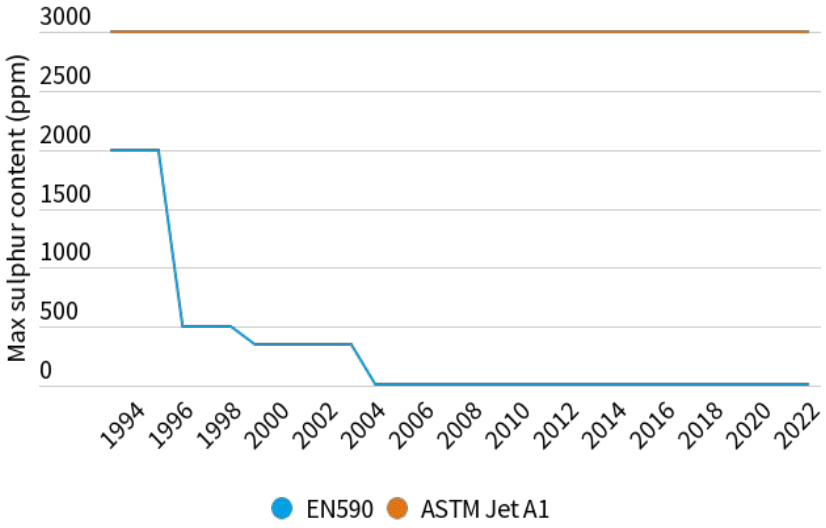
11 January 2010

Cost quantification of health impact - EASA 2010

…but no action was taken due to unknown climate impact of HT fuels.

Since 2010, progress in scientific research has clarified many of those unknowns

Sulphur content in road diesel and jet fuel specifications



Way forward

- ★ Evidence is accumulating on the climate benefits of hydrotreating jet fuel
- ★ More and more studies are highlighting the air quality and health impacts of current jet fuel
- ★ The scientific community accepts that the impact of UFPs is serious
- ★ Europe needs to take ambitious action
  - ○ Taking the steps to mandate HT jet fuel
  - ○ Improving the Air Quality Directive (AQD) to ensure UFP emissions are properly measured and limited

“There is no safe level of air pollution”

Thank you!