TRA
TRANSPORT RESEARCH ARENA
LISBON 2022

AVIATOR Project:

Assessing aViation emission Impact on local Air quality at airports: TOwards Regulation

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Outline

1. Rationale
2. AVIATOR Project
3. Aims & Objectives
4. Experimental campaigns
5. Conclusions

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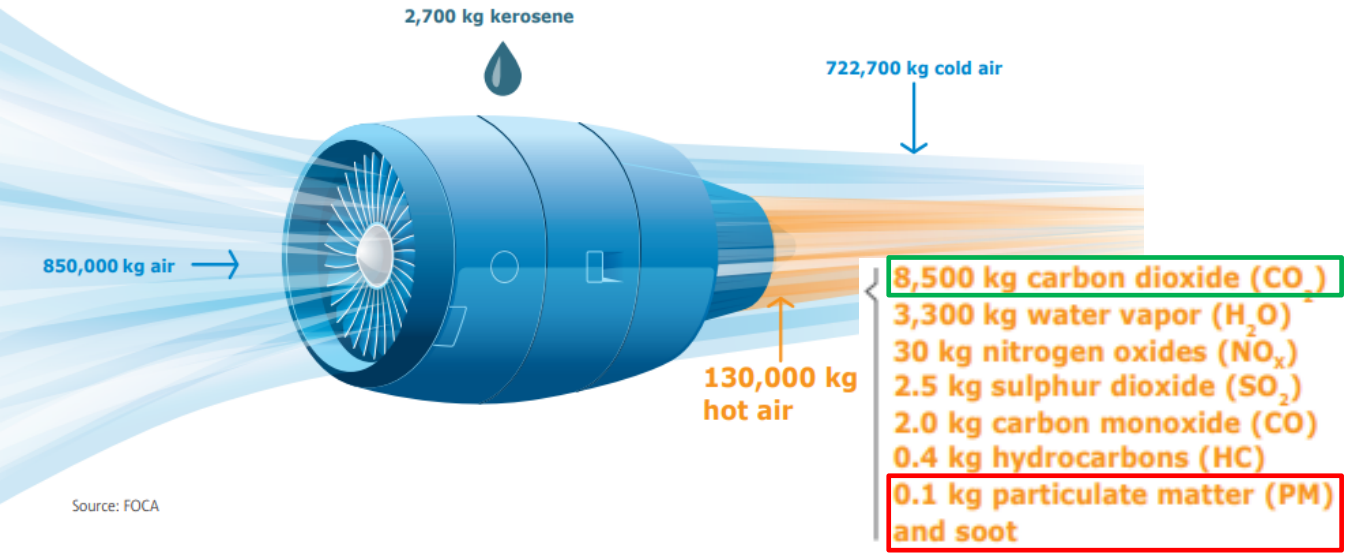
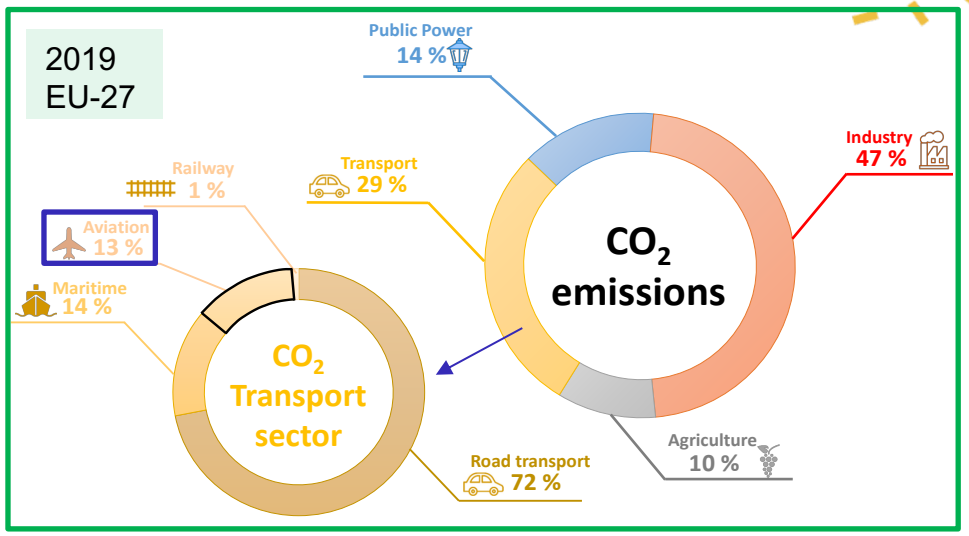
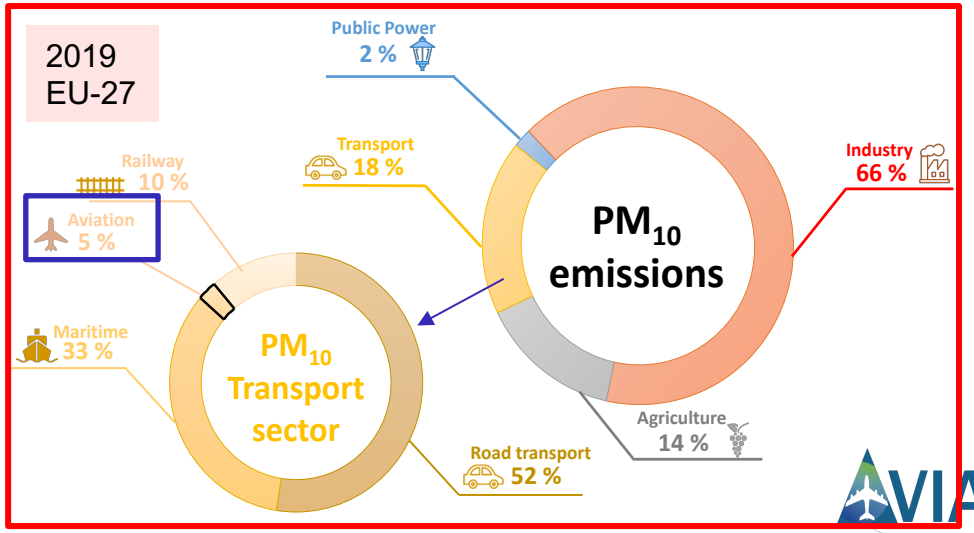
1. Rationale – Aircraft emissions





Source: https://www.ceip.at/webdab-emission-database/reported-emissiondata



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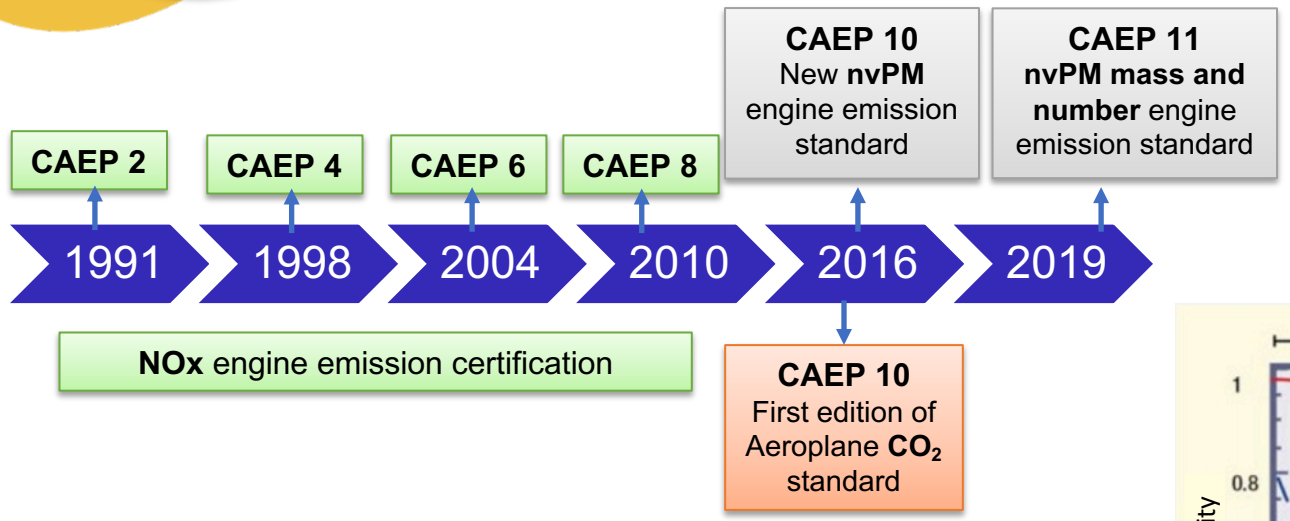
1. Rationale – Aircraft emission Regulation

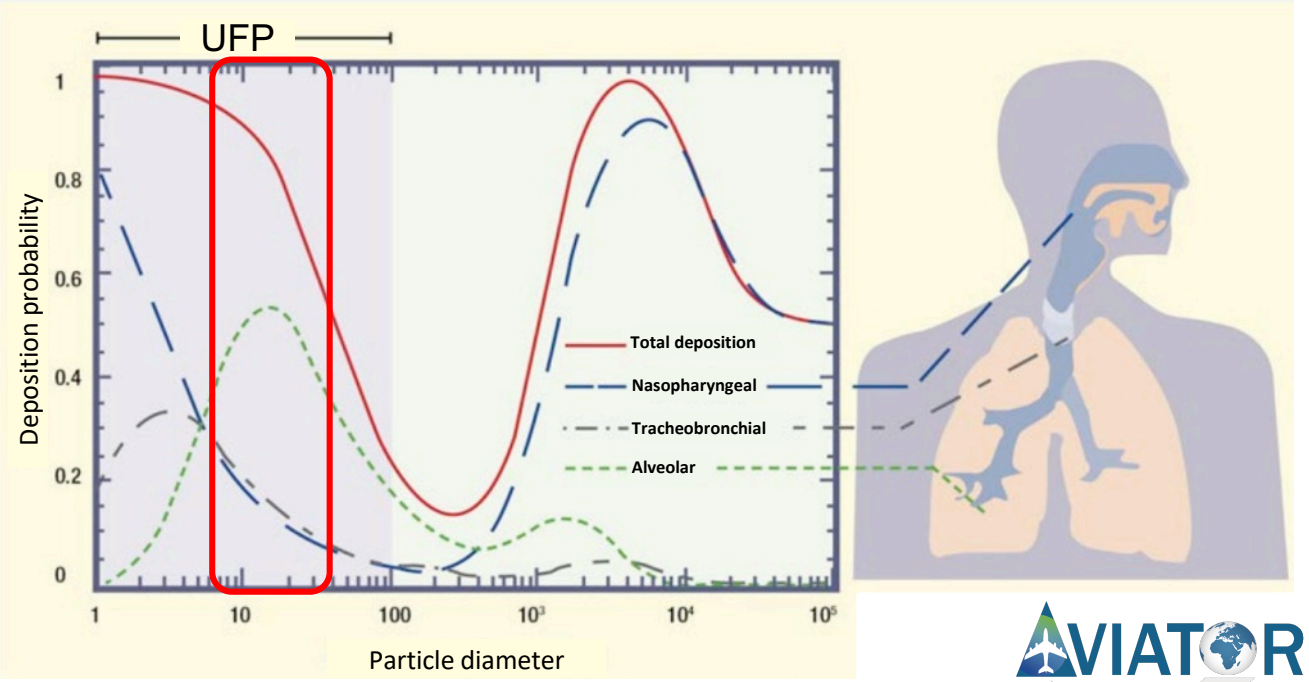


UFP or $PM_{0.1}$ contribute a small mass fraction to overall airborne PM loading.

Due to their small sizes (< 100 nm), UFP can reach the circulatory system.

UFP number is of increasing interest.

The EU Ambient Air Quality Directives contain regulatory limits for PM_{10} and $PM_{2.5}$, **but not for ultrafine particles**.



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2. AVIATOR Project

@aviatorproject

https://aviatorproject.eu/

AVIATOR is a multinational scientific study which provides the most detailed understanding of aircraft emissions and their associated impact on airport air quality at large-scale, paying especial attention to main gases, UFP and VOCs.

Consortium

17 partners (7 countries)

Advisory Board

Call: H2020-LC-MG-1-1-2018

2019 – 2023

Work programme: InCo flagship on reduction of transport impact on air quality

Total budget: 6.29 M€

Coordinated by **INTA**
Spain

Funded by European Union's Horizon 2020 Research and Innovation Programme under Grant Agreement Nr. 814801

3. AVIATOR Project: Aims & WP structure

Aim 1. Develop Measurement Systems for Aircraft Engine Emissions including volatile precursor and total PM

WP2

Certified test-cell engine exit and in-stack plume measurements

WP3

On-wing engine exit and downstream plume with APU measurements

WP4

Ambient measurements and sensor network development

Aim 2. Create new knowledge on Aircraft exhaust and Airport pollutants Modelling

WP5

Mathematical and numerical modelling of plume microphysics, chemistry and dynamics

WP6

Numerical pollutant modelling and transport in and around airports

Aim 3. Bridge the gap between Aircraft Engine Certification and Local Air Quality (LAQ) Regulations

WP7

Regulation

WP8

Communication, Dissemination and Exploitation

Aim 4. Improve Protocols and Guidance for Air Quality and Health

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WP2 – Test-cell engine exit and in-stack plume measurements

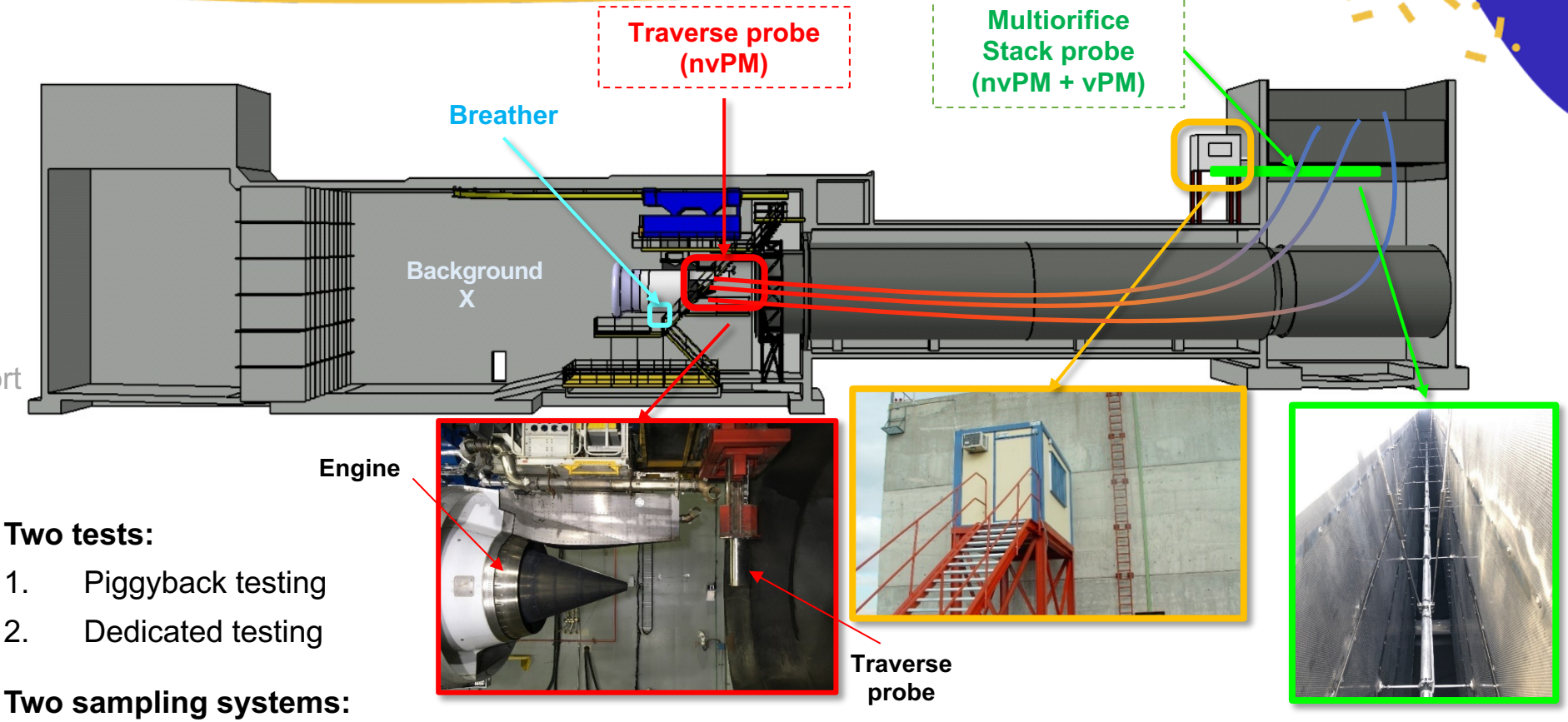
INTA's Test bench in Madrid (Spain)

Aim 1

Measurement campaigns

WP2: Test-cell | WP3: On-wing | WP4: Ambient airport

To develop approaches for **measurement protocols at engine exit and downstream** within the evolving plume, across a range of operational LTO cycle conditions at INTA's indoor testbed.



Two tests:

1. Piggyback testing
2. Dedicated testing

Two sampling systems:

1. **Comprehensive system** (EASA reference system + SOA gas precursors + VOCs + vPM + chemical composition)
2. **Baseline system** (number, mass and size of nvPM, vPM and TPM + CO_2)

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WP3 – On-wing engine exit and downstream plume measurements

Ciudad Real Airport (CRIA) (Spain) → Summer: Jul 2021
→ Winter: Jan 2022

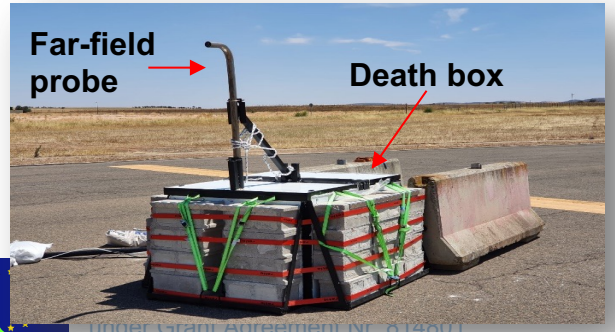
Aim 1

Measurement campaigns

WP2: Test-cell | **WP3: On-wing** | WP4: Ambient airport

To measure on-wing main engine emissions at engine exit and downstream plume.
To measure emissions from using 30% SAF fuel.

Far-field probe → TPMn, nvPMn, nvPMm, TPM size distribution, CO_2, SO_x.



Near-field probe

TPMn, nvPMm, TPM size distribution, VOCs, THC, CO_2, SO_x. NO_X, chemical characterisation.

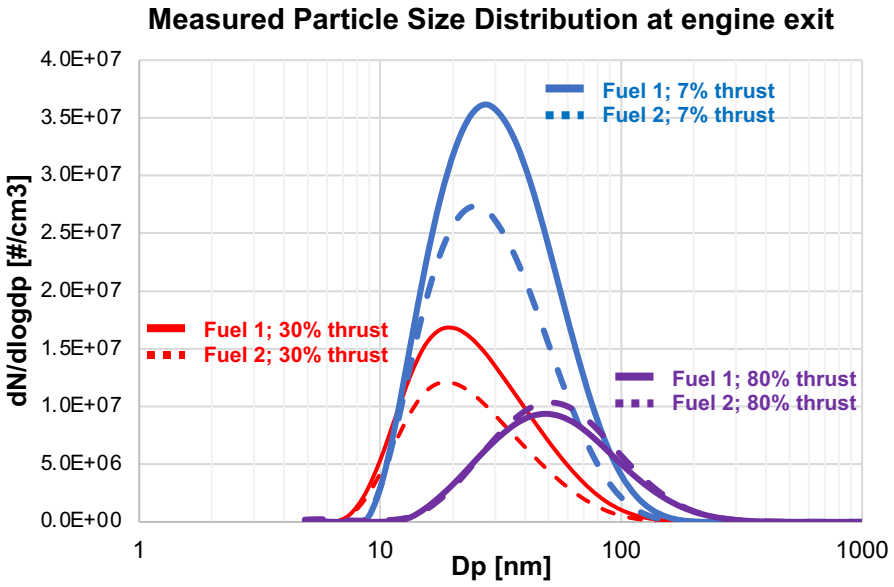
under Grant Agreement N°. 814801

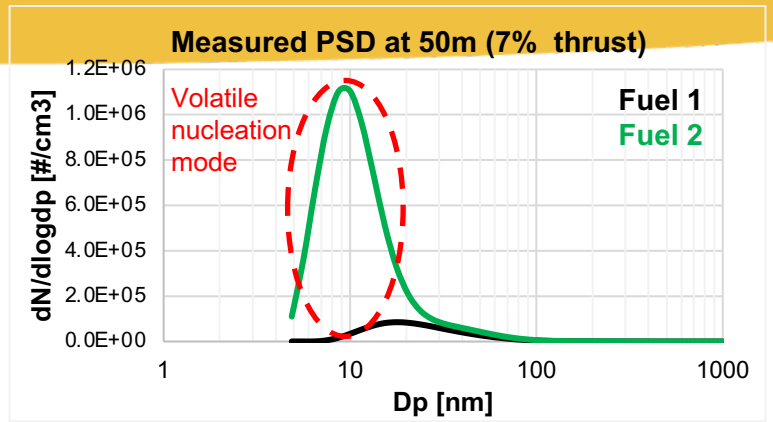
WP3 – On-wing engine exit and downstream plume measurements

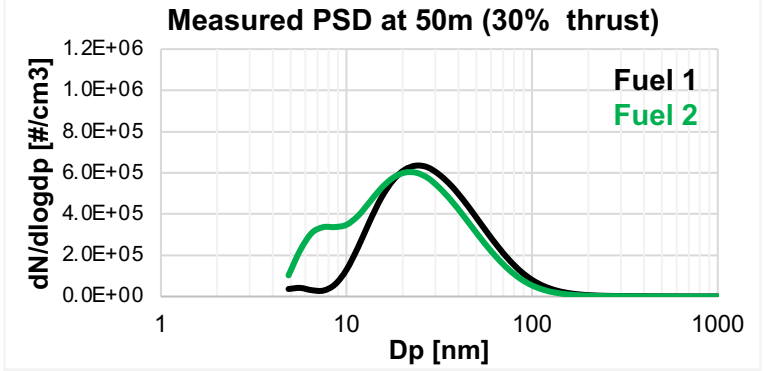
- Investigate climate impacts: Summer / Winter test campaigns (no engine degradation + identical fuel)
- Investigate fuel composition impacts: Hydrogen content (%); Sulphur content (ppm)

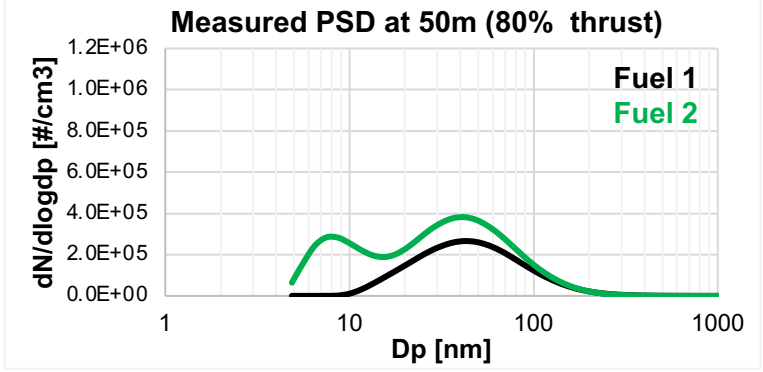
Example of fuel impacts

- Fuel 1: Hydrogen content 13.77%; Sulphur 65 ppm
- Fuel 2: Hydrogen content 14.27%; Sulphur 307 ppm









Key results:

- Prominent volatile UFP nucleation mode downstream for engine exit.
- Greater prominence of volatile peak at low thrust is related to temperature and transport time.
- Number concentrations for vPM >> nvPM within a relatively short distances.

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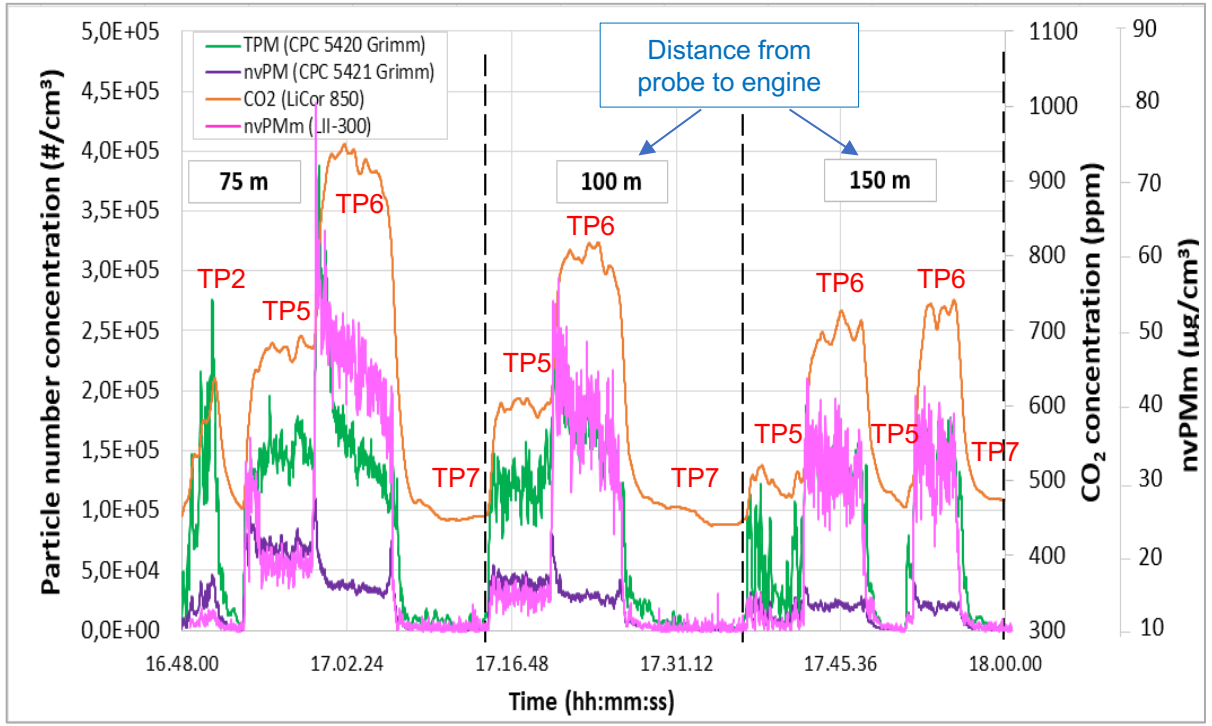
WP3 – On-wing engine exit and downstream plume measurements

Example of far-field probe measurements

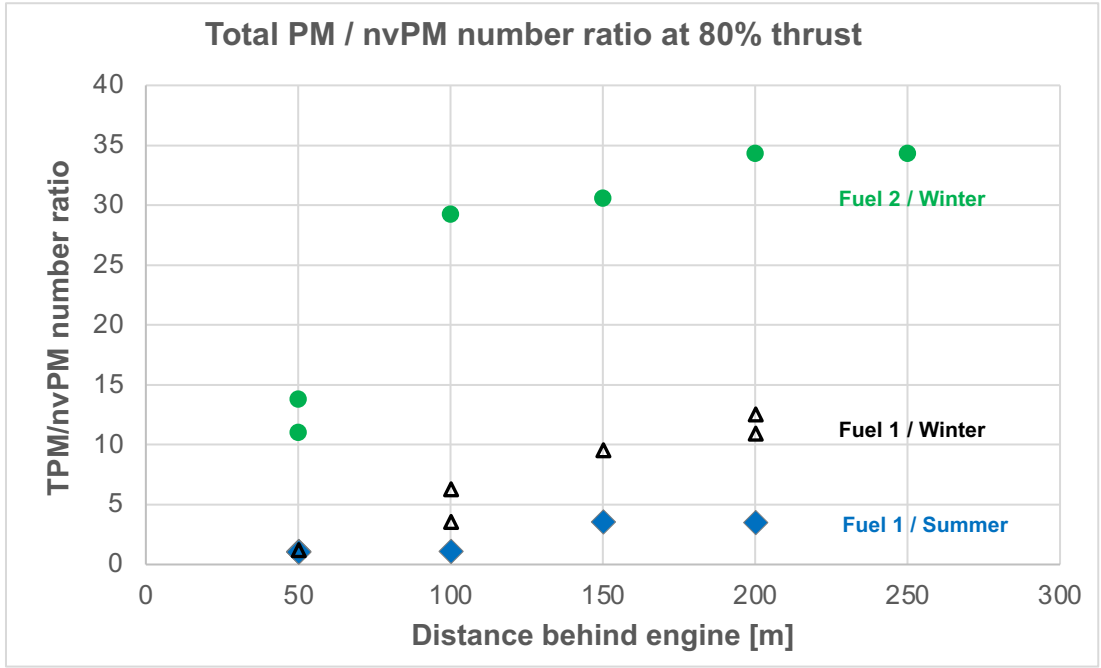
Ambient wind adversely affects measurement quality



Power Engine from Flight Idle up to 80% N1

Key results:

- TPM/nvPM ratio increases with distance
- TPM/nvPM ratio are higher for higher sulphur fuels
- TPM/nvPM ratio is higher in winter (temperature, humidity effects?)



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WP4: Ambient measurements and sensor network development

Aim 1

Measurement campaigns

WP2: Test-cell

WP3: On-wing

WP4: Ambient airport

- To develop a proof of concept low-cost and low-intervention **sensor network**.
- To perform **hi-fi measurements** of air quality in and around 3 international airports: ***Madrid-Barajas, Zurich, Copenhagen***.

AVIATOR Low Cost Sensors

- PM_{10}
- $PM_{2.5}$
- UFP (10 – 300nm)
- VOCs
- CO, CO_2
- NO_x
- SO_x
- O_3

LCS meas.

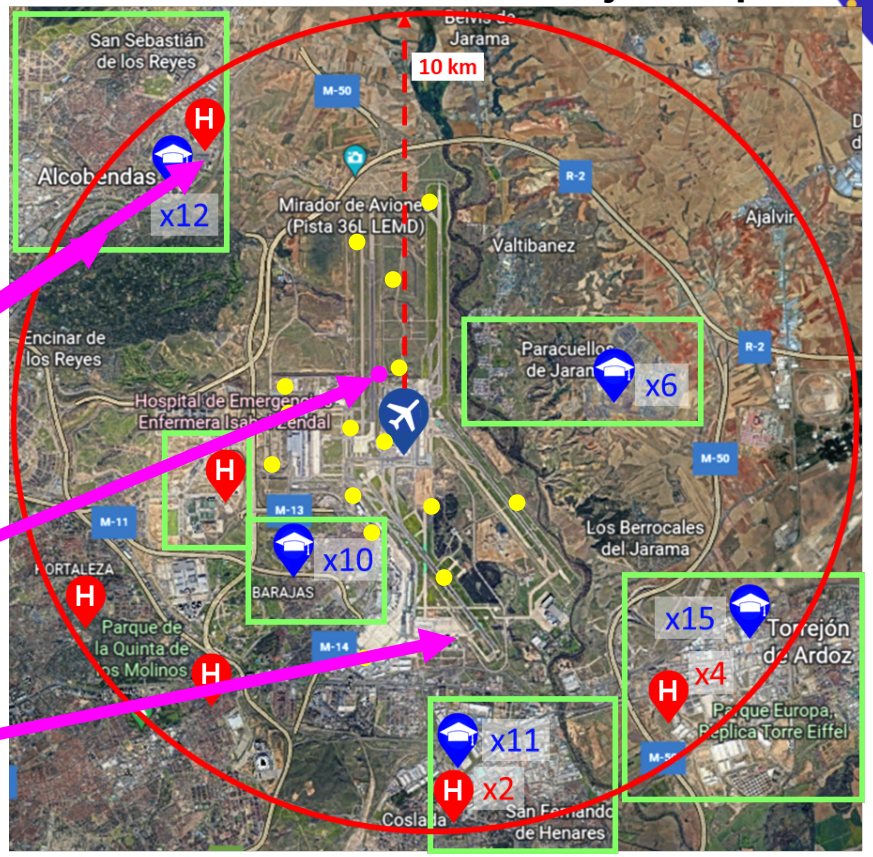
Madrid airport x15 nodes

High fidelity meas.

High fidelity meas.

High fidelity meas.

Madrid Adolfo Suárez Barajas Airport



Residential area

School

Hospital

Low cost sensor network

High fidelity measurements

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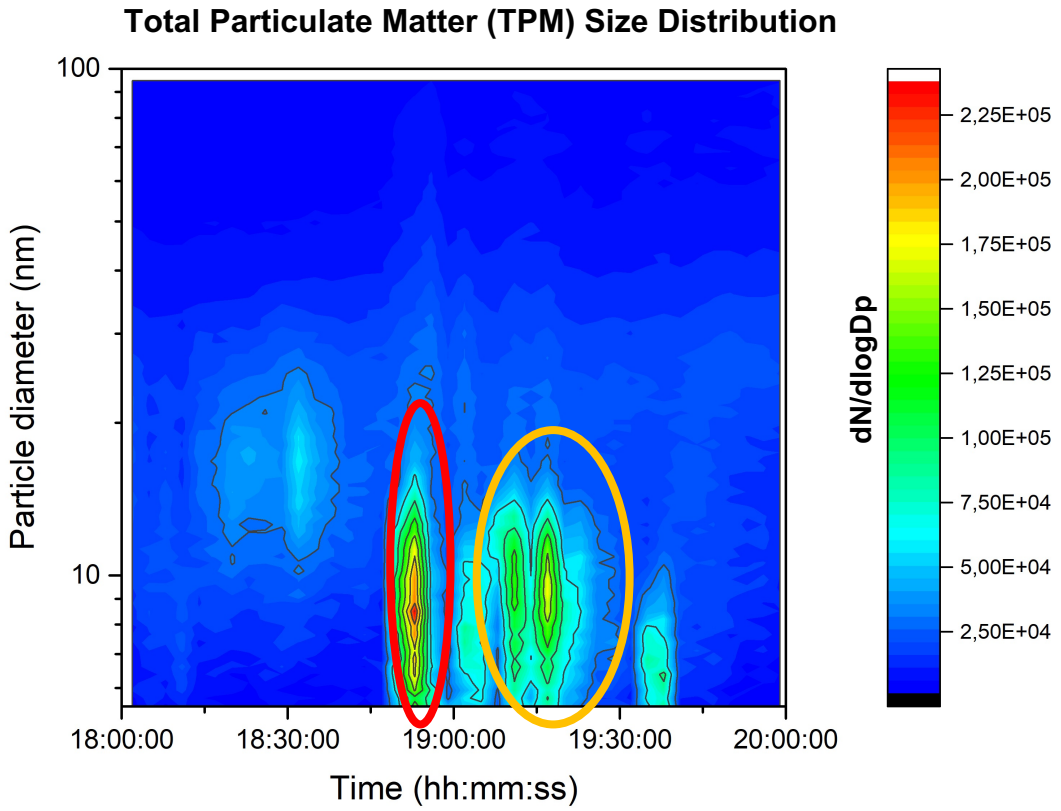
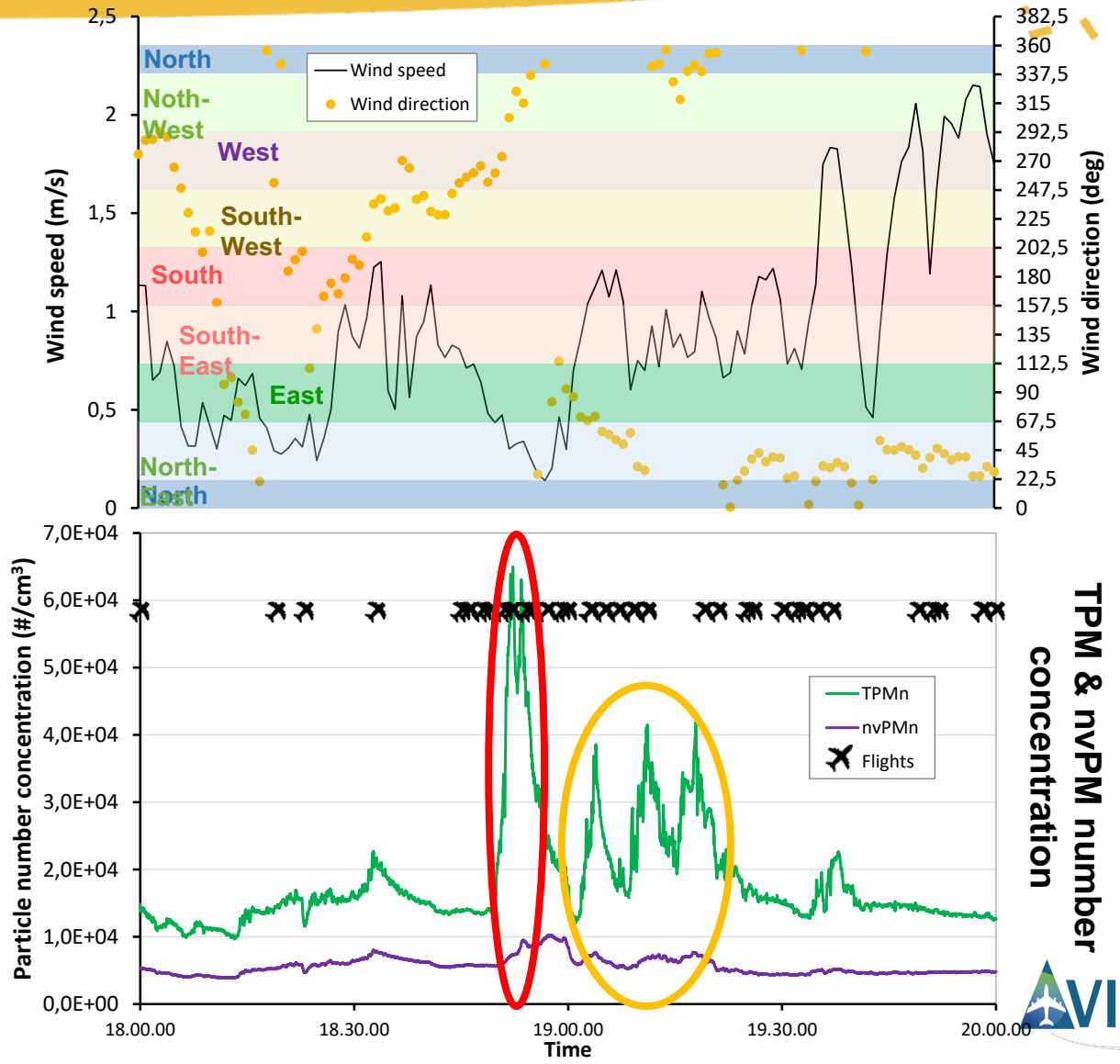
WP4 – Some results from Madrid Airport

12th October 2021





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WP5: Modelling of plume microphysics, chemistry and dynamics
WP6: Pollutant modelling and transport in and around airports

CFD intra-engine box model

PROVIDES exhaust concentrations

REQUIRES engine and aircraft specifications, and ambient conditions

MADE3 chemical box

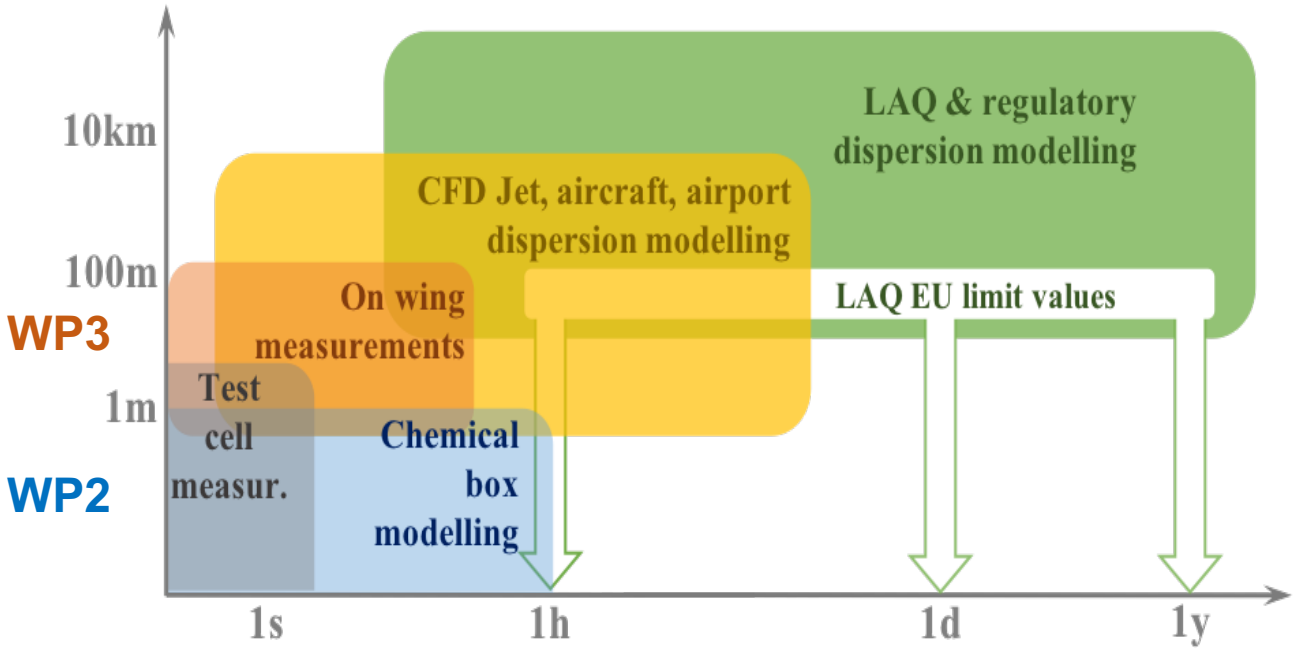
PROVIDES EIs and conversion rates for vPM and nvPM

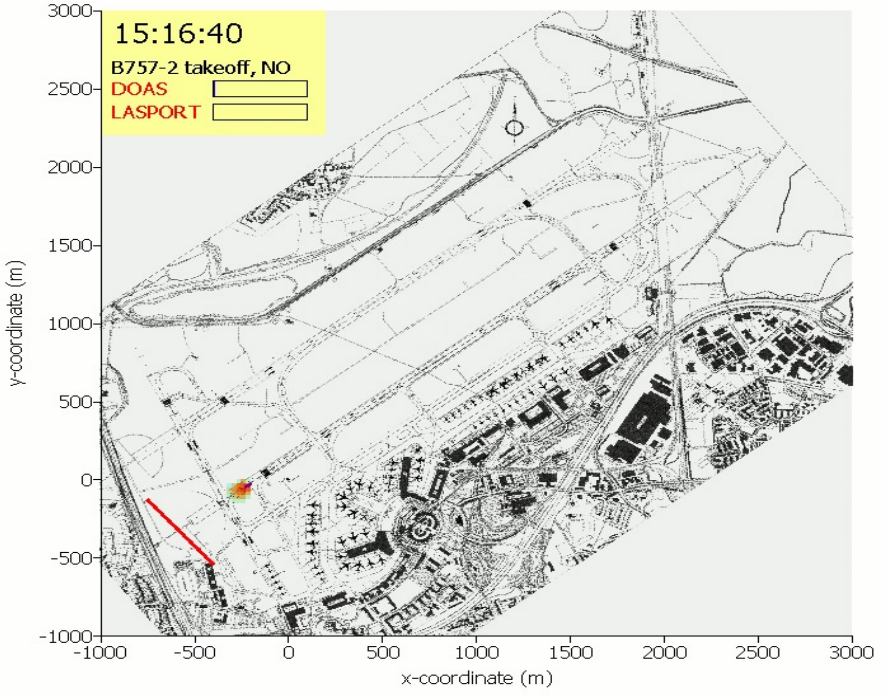
REQUIRES ambient conditions, exhaust concentrations

LASPORT / CEDRE

PROVIDES concentration maps at and around airports.

REQUIRES EIs and conversion rates.





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Conclusions

- **Emissions from the engines oil breather can contribute to the total vPM loading at downstream distances (not previously characterised).**
- **Fuel properties are a key determinant of nvPM and vPM:**
  - **Higher hydrogen content reduces regulatory nvPM (at lower thrusts);**
  - **Higher fuel sulphur increases propensity for vPM formation.**
- **For many fuels, mass and number concentrations for vPM >> nvPM within a relatively short distance.**
- **Climate / ambient conditions impact the rate of vPM formation.**
- **In addition, there is some indication that climate / ambient conditions impact nvPM emissions.**

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Thank you!

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