EASA CAQIII

Workshop addressing **‘Cabin Air Quality Research’**

Cologne, January Tuesday 17th – Wednesday 18th , 2023

1

Foreword: Why CAQIII?

2

Introduction to the CAQIII project

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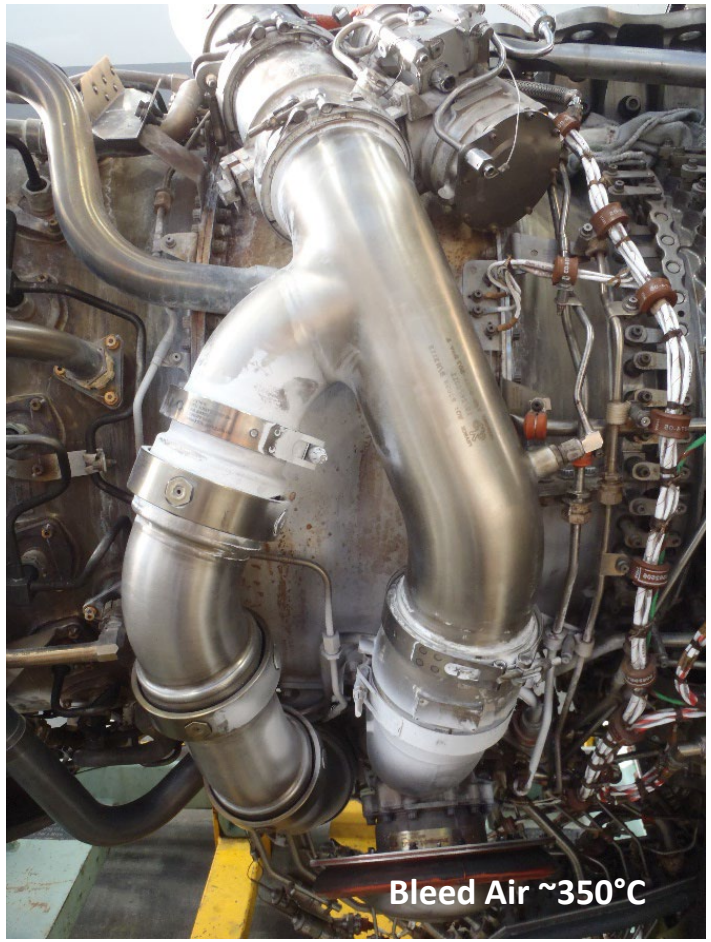
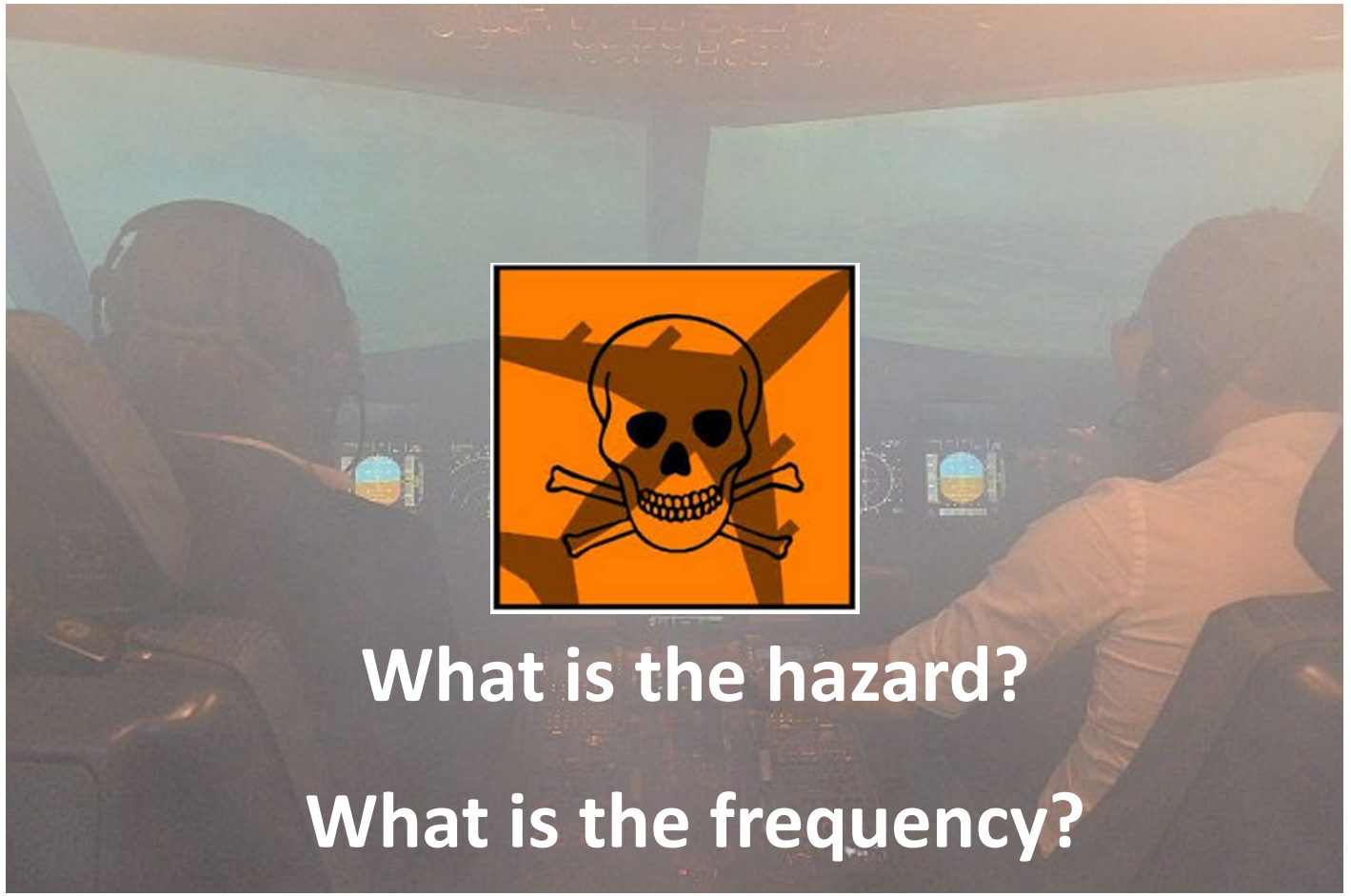
Why CAQIII?

Bleed Air Contamination with Engine Oil



Oil Fumes / Fume Events



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Why CAQIII?

Risk Assessment

Only objective: Oil events and toxic effects of oil vapors!

CABIN AIR QUALITY III

Workshop Task: What are the definitions for Air Quality Event, Fume Event and Smell Event?

What counts?

RISK = HAZARD x FREQUENCY

What is toxic?

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Why CAQIII?

Risk Assessment

CABIN AIR QUALITY III

Decision Body

Authorities in Aviation (FAA, EASA)

RISK = HAZARD x FREQUENCY

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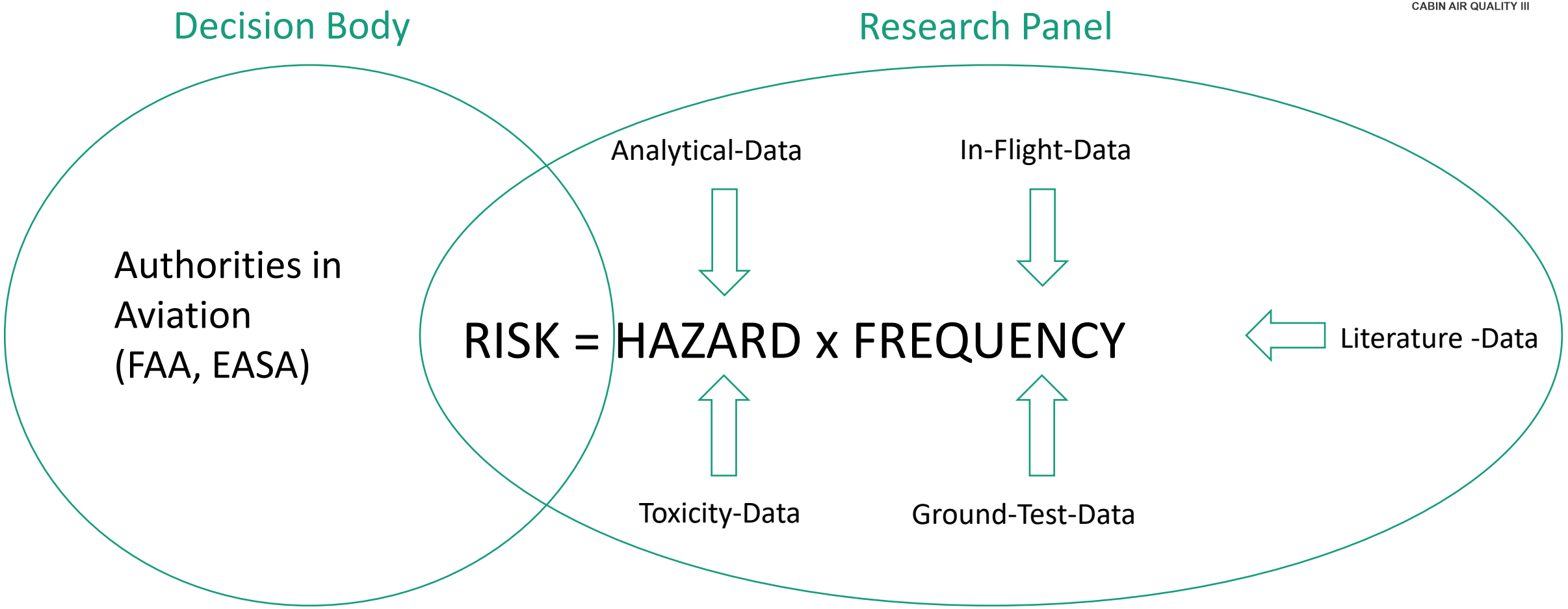
Why CAQIII?

Data Generation for Risk Assessment



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What will the CAQIII project do – and not do?

CABIN AIR QUALITY III

"The regulatory system on aircrafts and chemicals is as it is – with regulation being based on scientific evidence (data).

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Introduction to the CAQIII project

“Cabin air quality assessment
of long-term effects of contaminants”

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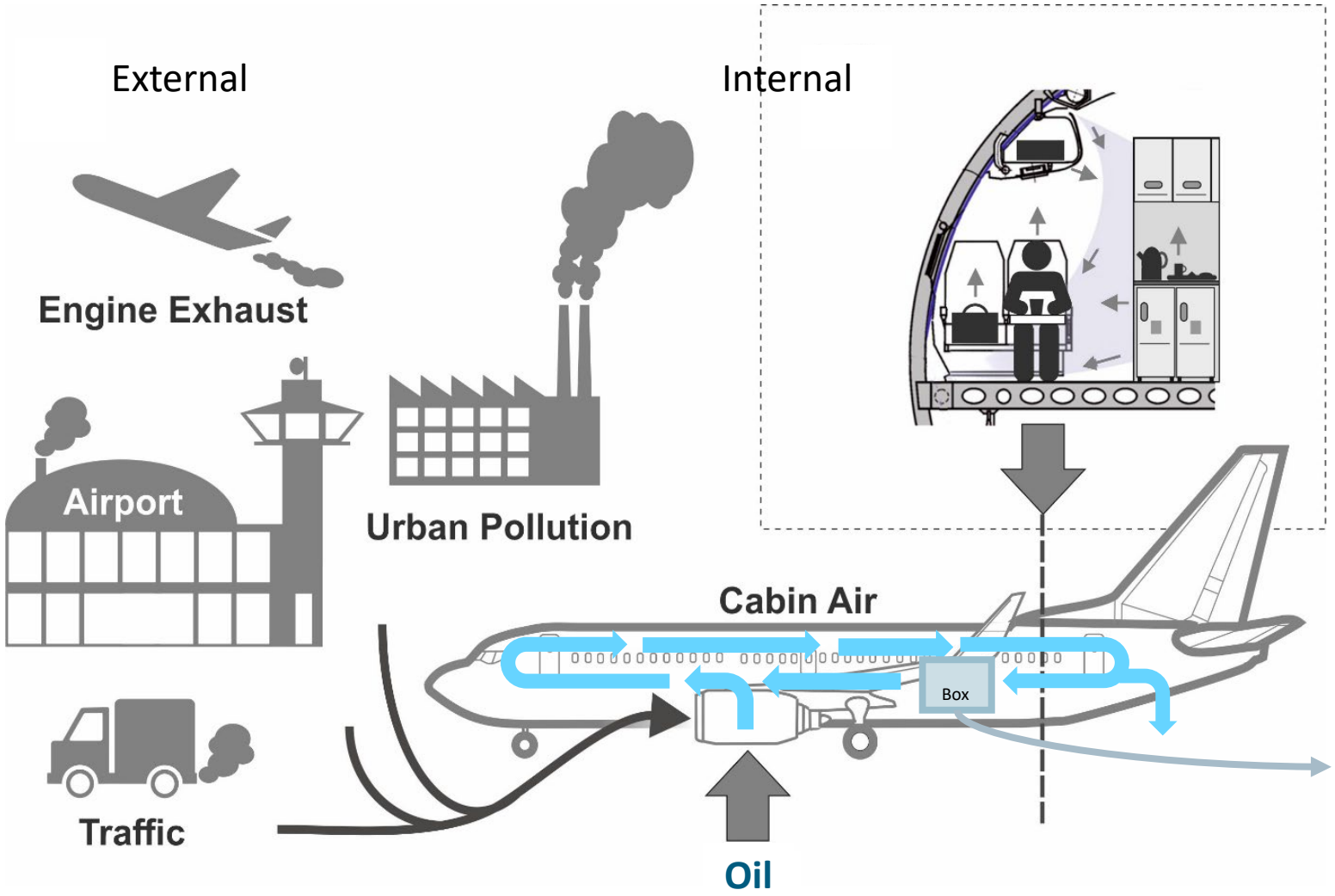
Introduction to the CAQIII project

Previous Campaigns



CAQI and CAQII (**B787**)
Objective:
Cabin Air Quality and oil events during flight

Result:
Cabin air quality for normal condition is good

„no oil-related fume event“

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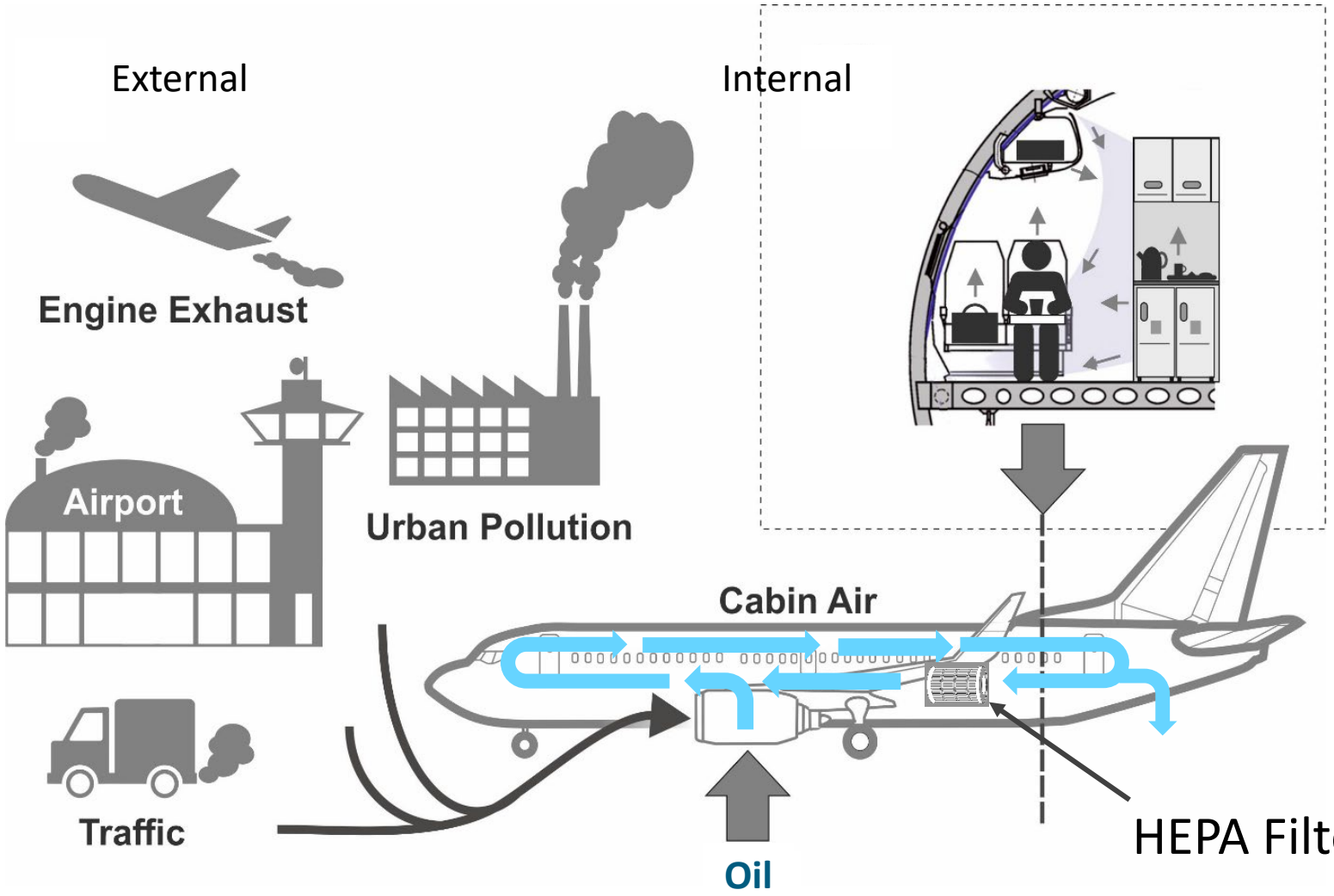
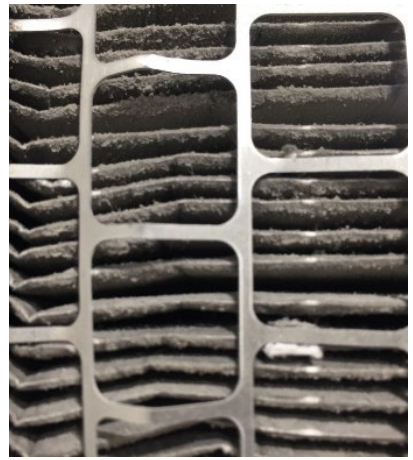
Introduction to the CAQIII project

HEPA-Filter Sampling Strategy



CAQIII



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Introduction to the CAQIII project

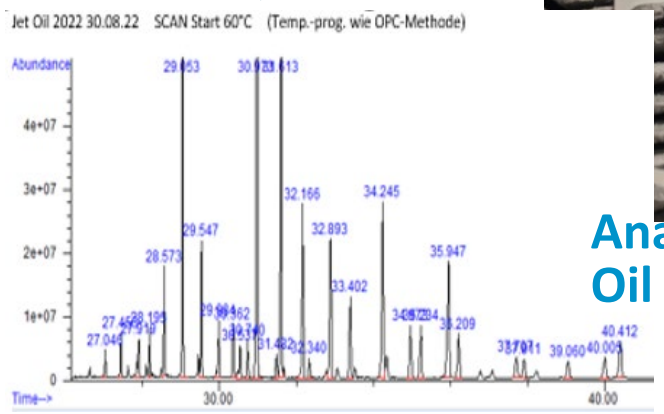
HEPA-Filter Sampling – General Principle

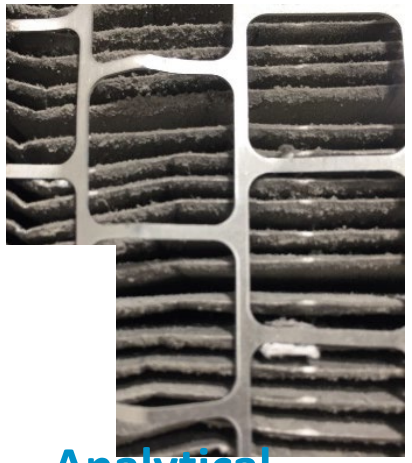
CABIN AIR QUALITY III

Eckels et al. 2014 »»» 4 TCPs isomers & some Oil esters

CAQIII »»» 10 TCPs, Oil esters, Carboxylic acids, Aldehydes, VOC, SVOC, Heavy Metals & Unknown Screening

Oil Fumes





Analytical Oil Characterization

Analytical Oil Fingerprint

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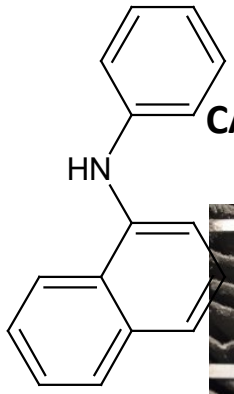
HEPA-Filter Sampling – Analytical Groundwork

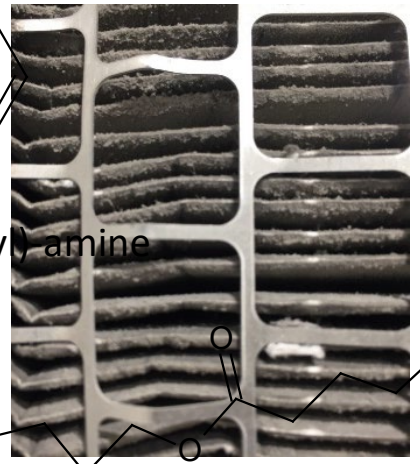
Extensive Analytics

CABIN AIR QUALITY III

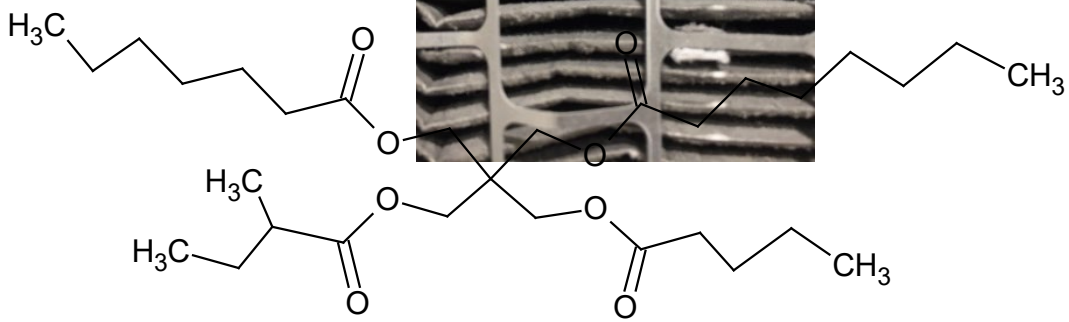
CAQIII »»» **10 TCPs, Oil esters, Carboxylic acids, Aldehydes, VOC, SVOC, Heavy Metals & Unknown Screening**



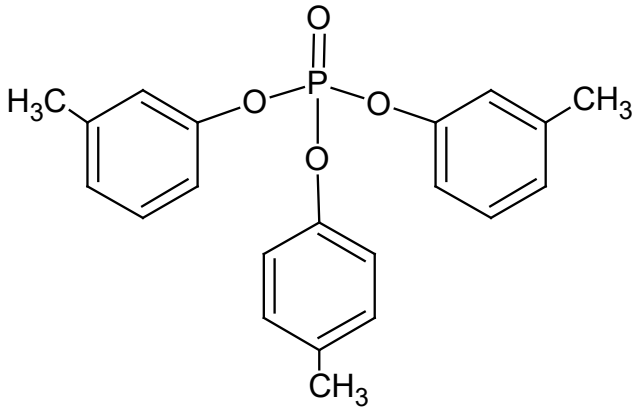
1% N-Phenyl-(1-naphthyl) amine



>5% alkylated Diphenylamines



95% Pentaerythritol-esters with acid-lengths between C5 and C12



3% mixture of mpTCP Isomers

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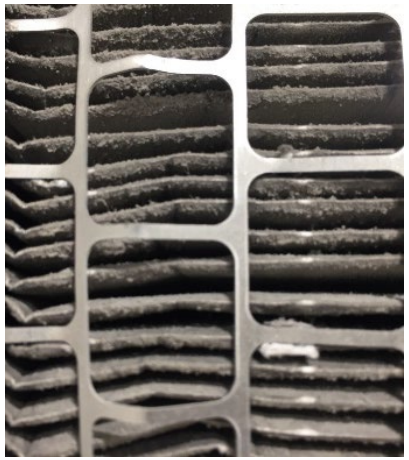
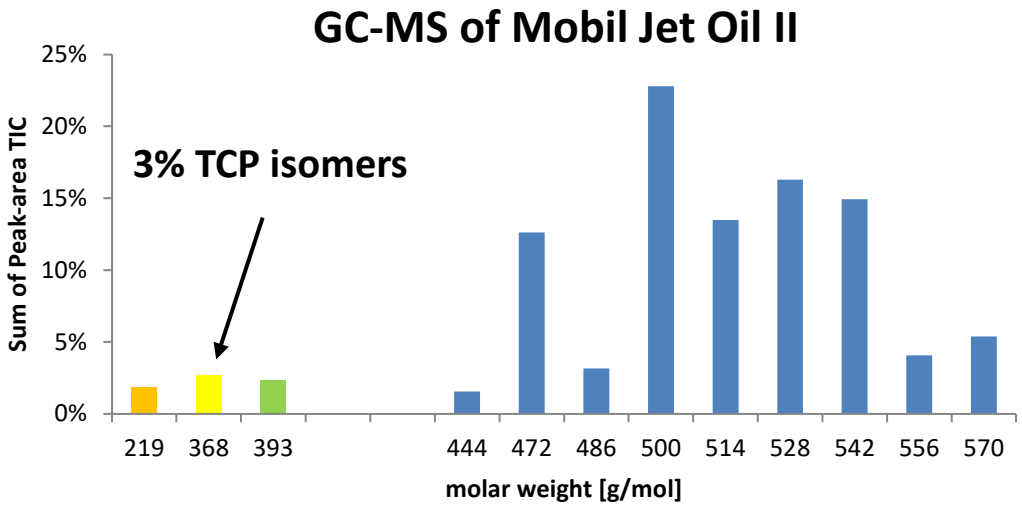
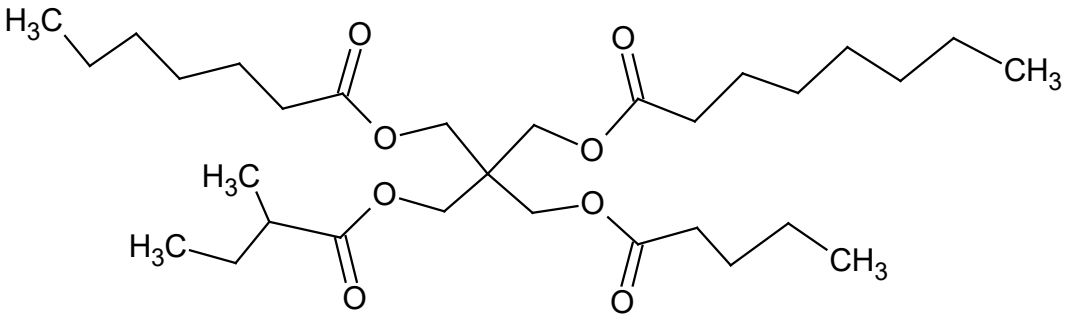
HEPA-Filter Sampling – Analytical Groundwork







95% Pentaerythritol-esters with acid-lengths between C5 and C12

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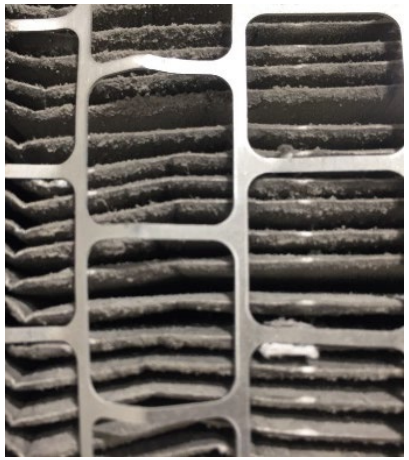
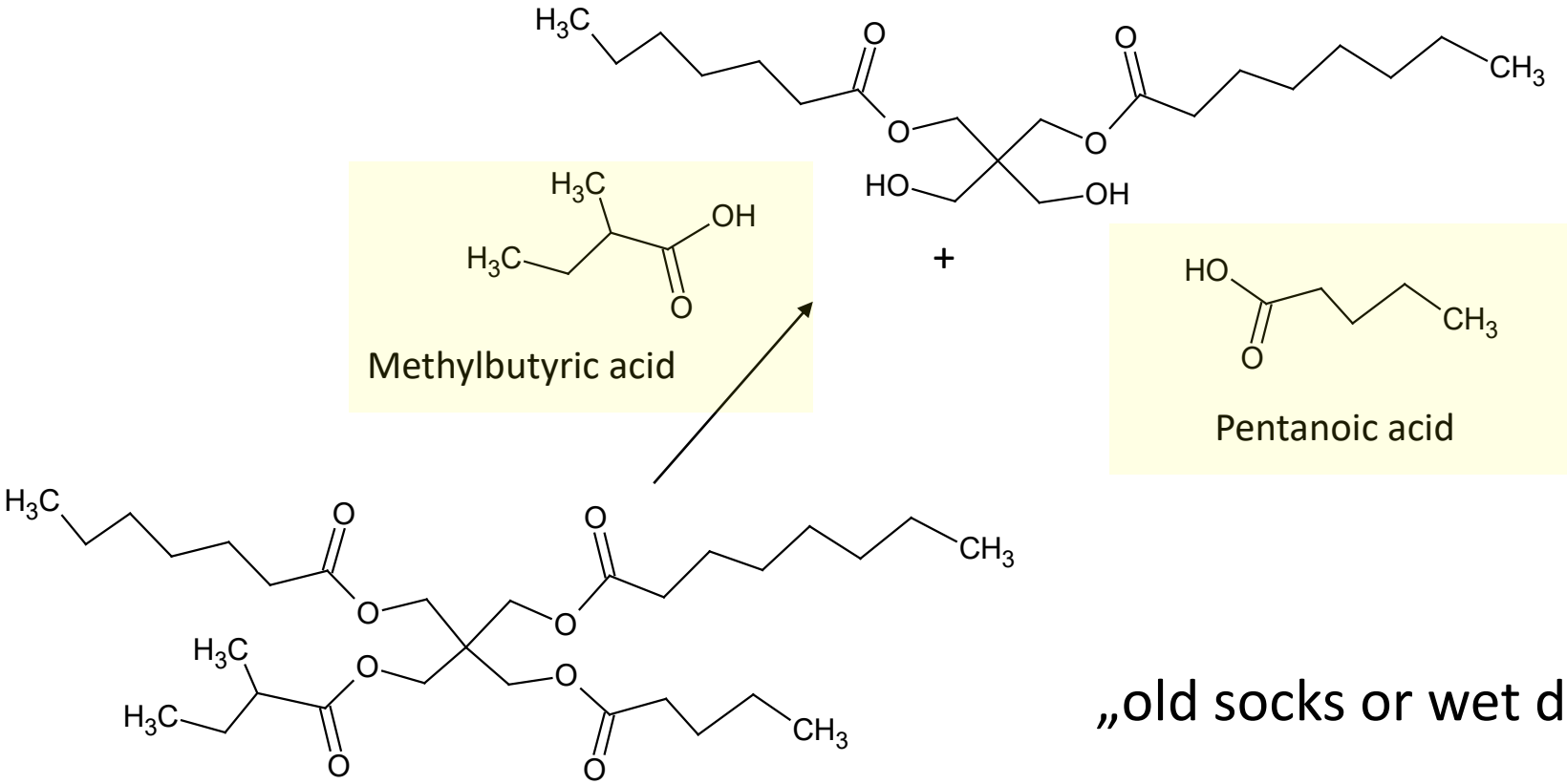
HEPA-Filter Sampling – Analytical Groundwork





95% Pentaerythritol-esters with acid-lengths between C5 and C12

„old socks or wet dog“

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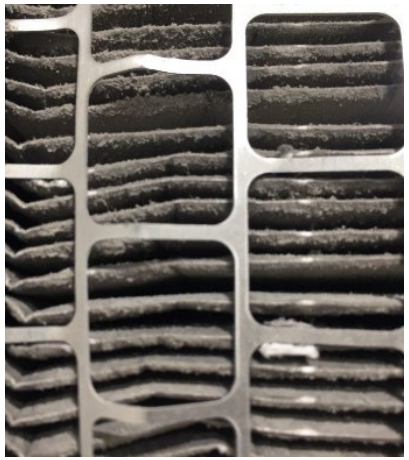
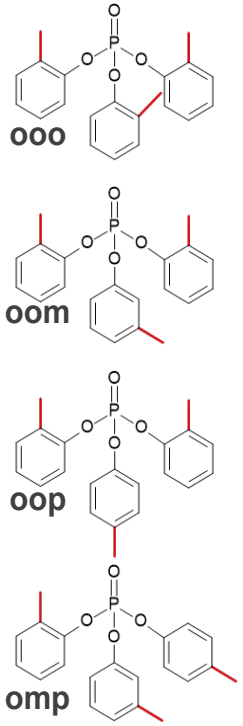
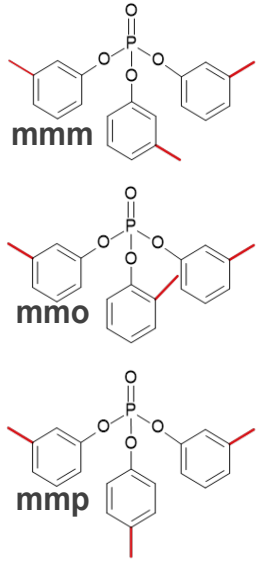
HEPA-Filter Sampling – Analytical Groundwork

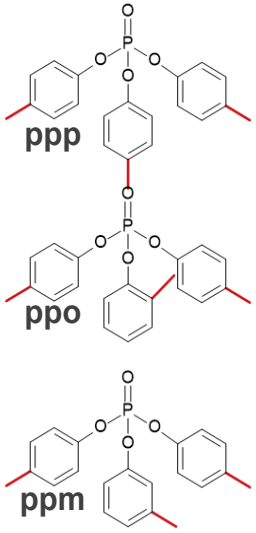
Extensive Analytics

CABIN AIR QUALITY III



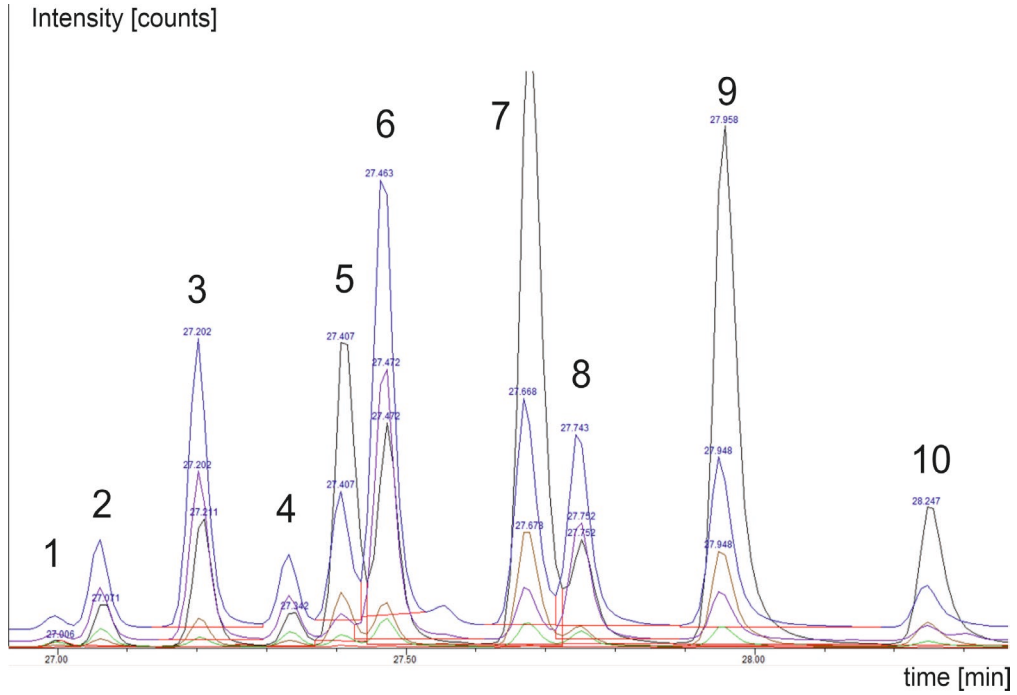






10 TCP isomers with m/z = 368

GC Resolution of the 10 TCP Isomers



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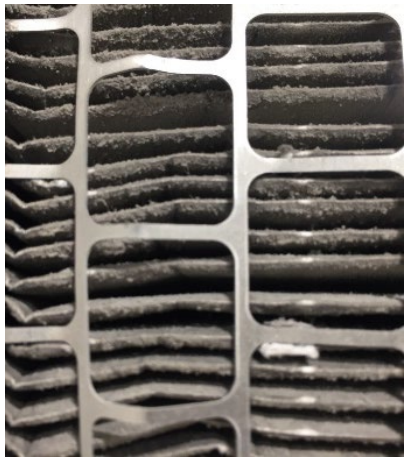
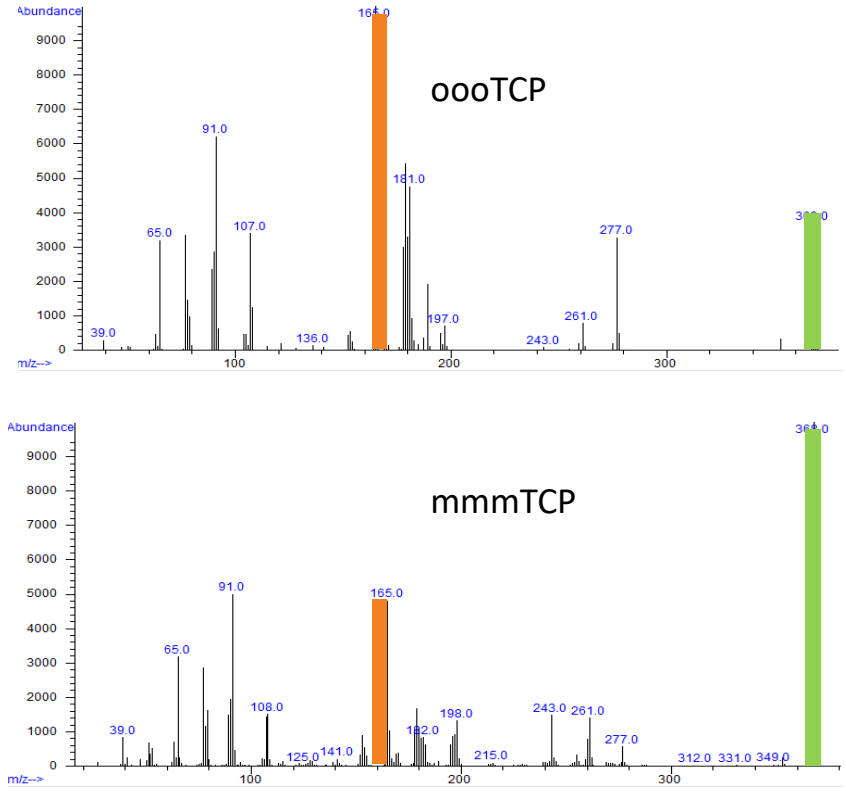
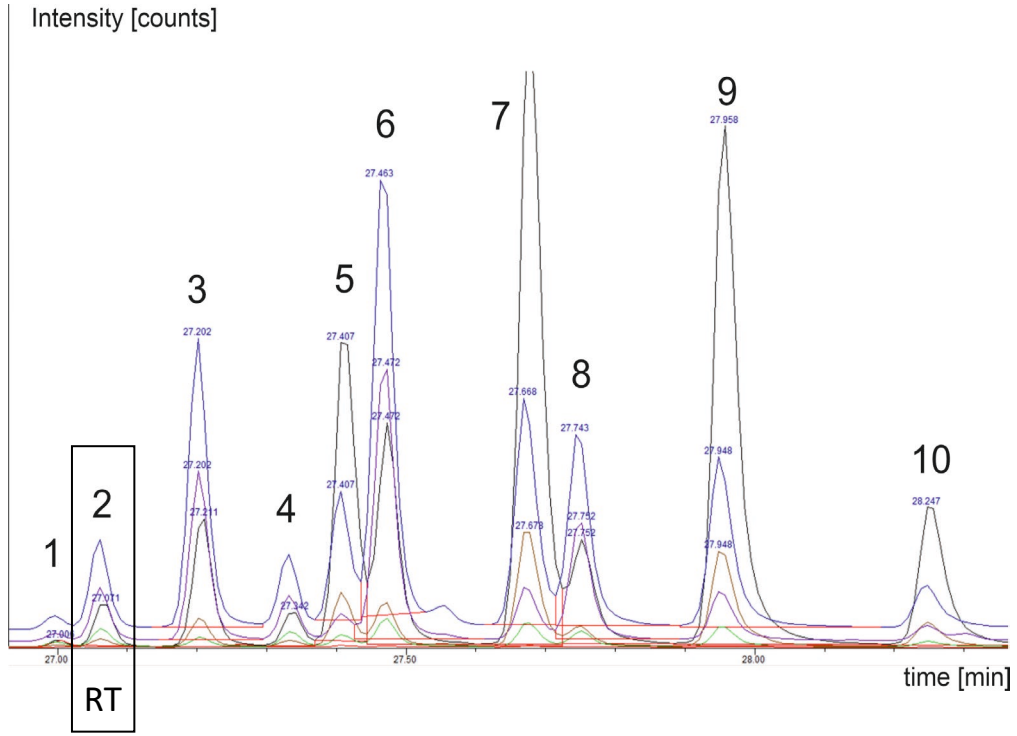
HEPA-Filter Sampling – Analytical Groundwork

Extensive Analytics

CABIN AIR QUALITY III







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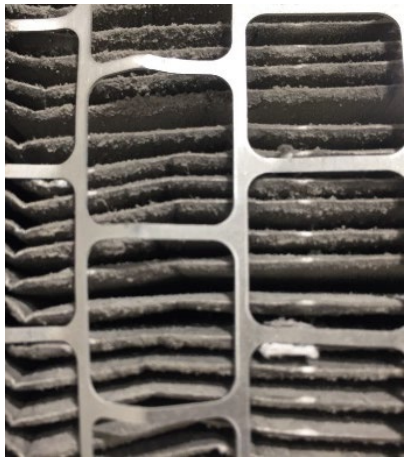
HEPA-Filter Sampling – Analytical Groundwork

Extensive Analytics

CABIN AIR QUALITY III



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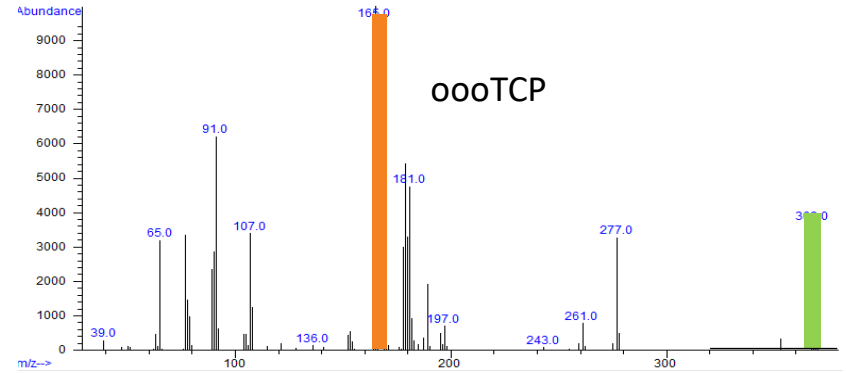

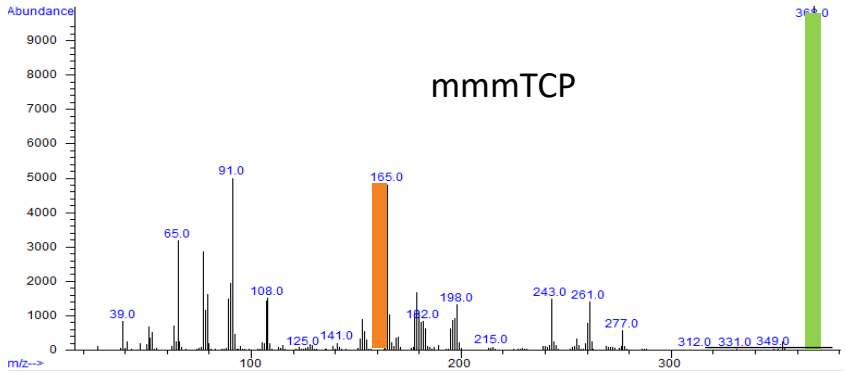

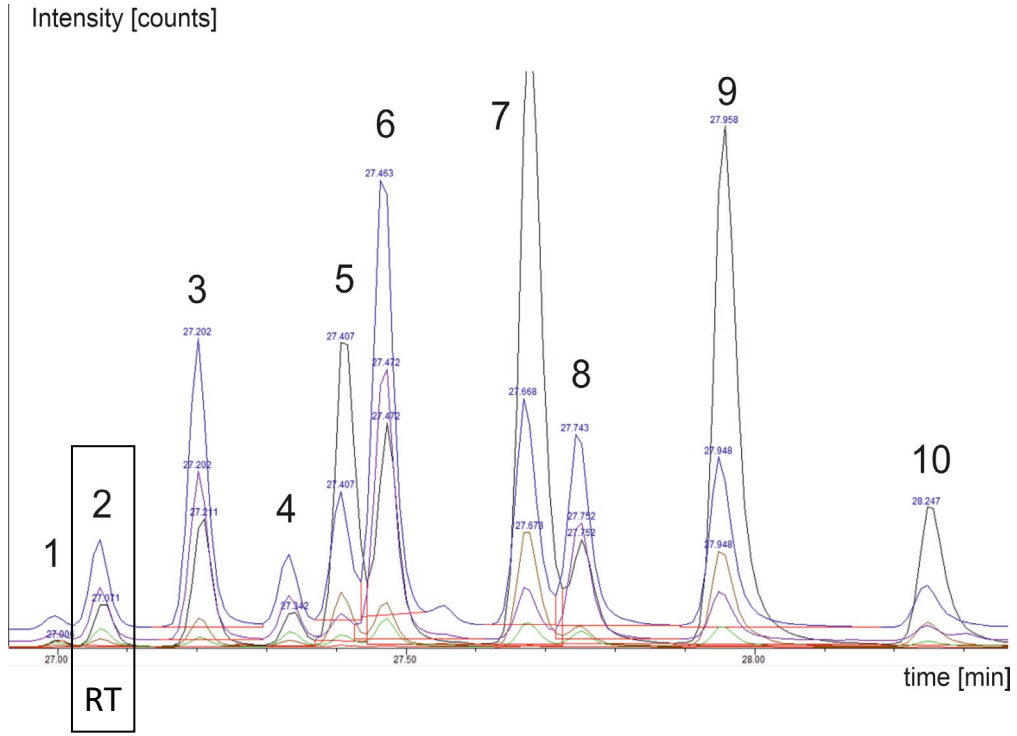

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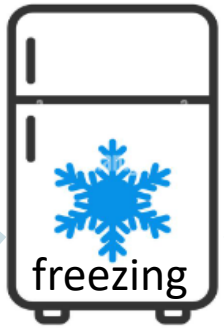
HEPA-Filter Sampling – Storage Procedure until Analysis

CABIN AIR QUALITY III



dismantling

vacuuming

HEPA-Filter sampling and analytical method development in progress

(first results expected at the end of 2023)

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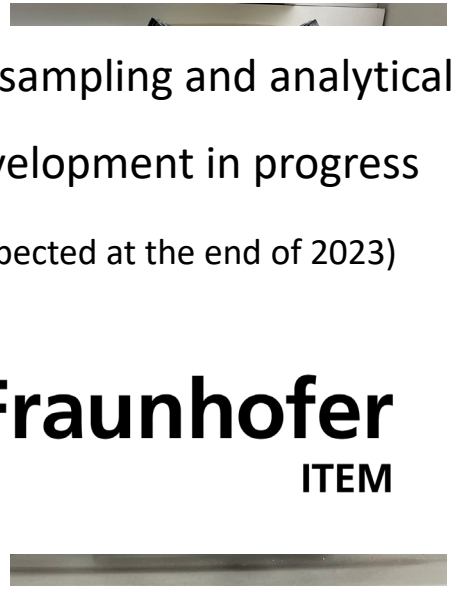

sieving

wrap up

punching

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HEPA-Filter Sampling – Sampling Protocoll

HEPA Filter Sampling Protocol (V001)

Airline:	**Aircraft type:**	**Contact person:**
Choose name	Choose type	Enter your name
Complaint	**Date of complaint:** ☐No	**Filter type:**
☐Yes ☐No	Click here to enter a date	Choose type

Information on the filter:

Filter Part. No.:	**Installation date:**	**Operating hours:**
Enter number	Enter installation date	Enter hours
Manufacturer:	**Date of removal:**	**Type of complaint:**
Choose manufacturer	Date of removal	Choose complaint

Information on the filter use:

Area of operation 1:	**Area of operation 2:**	**No. of takeoffs:**
Choose continent	Choose country	Enter number
Average flight time:		
Choose duration		

Information on complaint:

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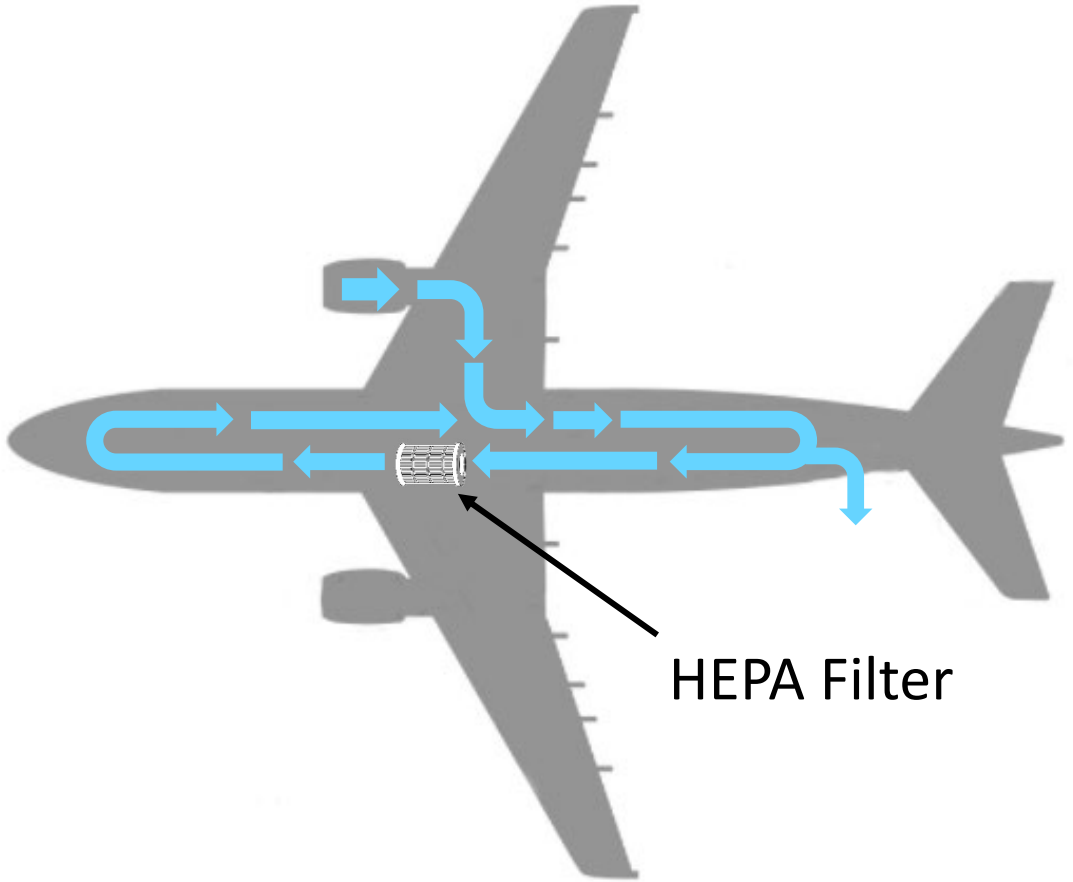
HEPA-Filter Sampling – i) In-Flight ii)

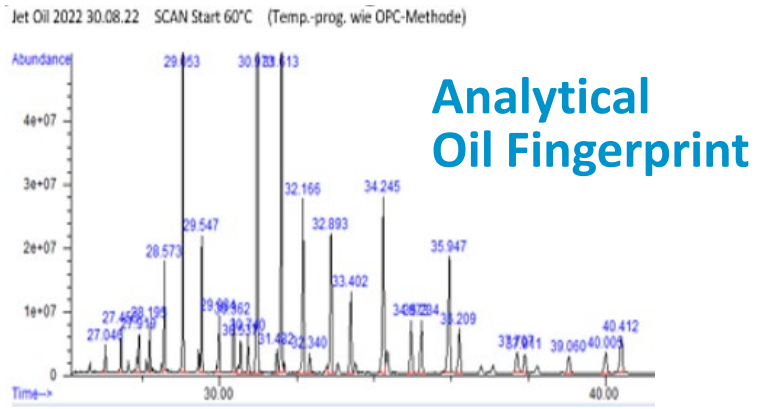
Extensive Analytics

CABIN AIR QUALITY III



ii) HEPA FILTER SAMPLING ON GROUND

- Aircraft fume event simulation (Toulouse)



i) HEPA FILTER SAMPLING IN-FLIGHT

- A320 fleet from participating air lines (fume event)
- Selected **B787** aircraft from participating air lines

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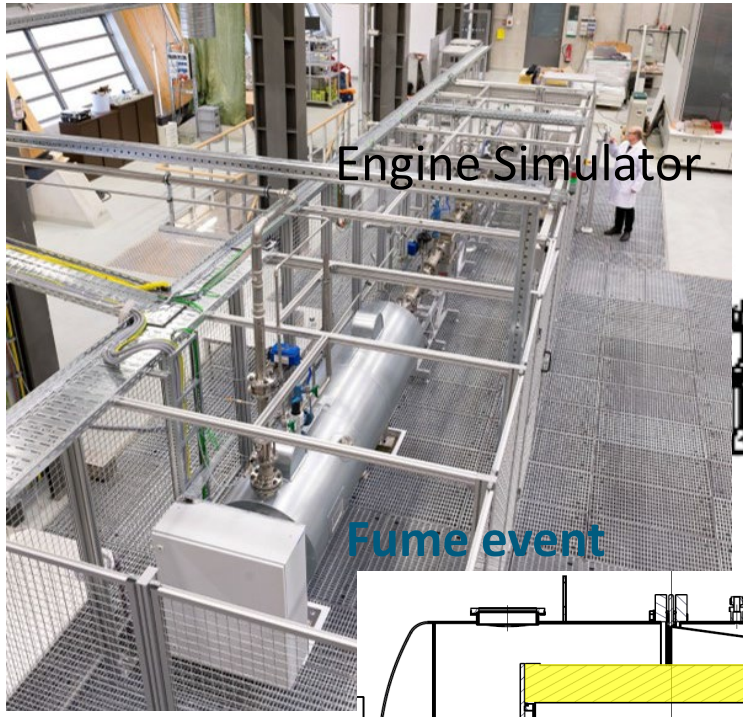
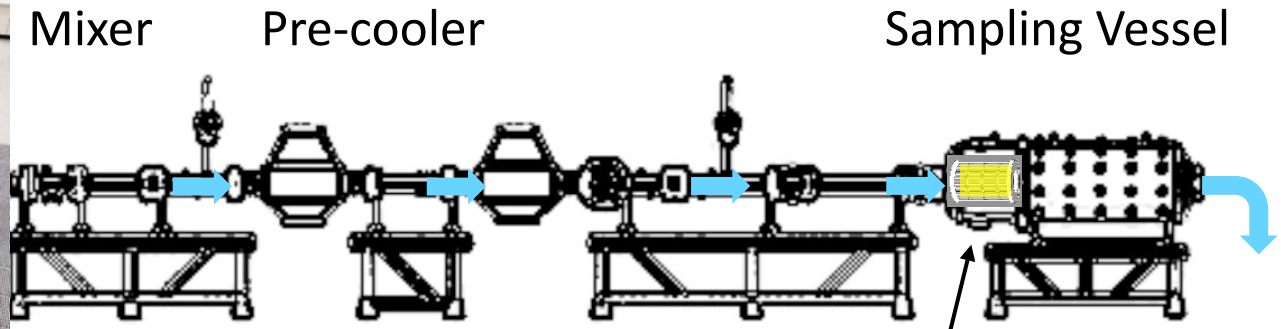
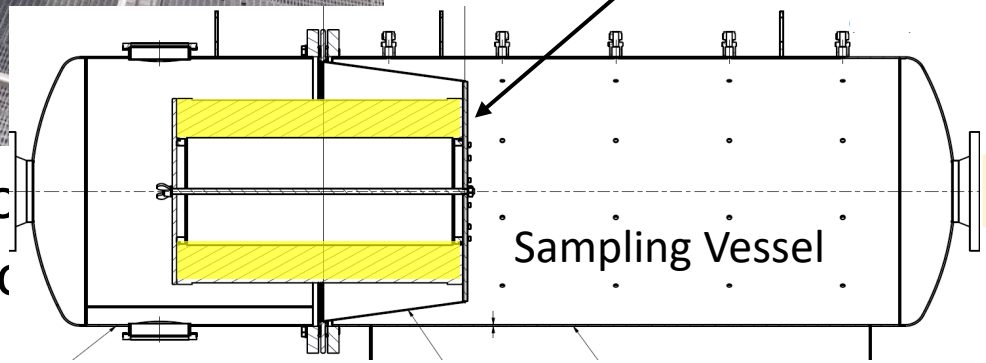
HEPA-Filter Sampling – iii) Fume Event Simulation without External Contamination

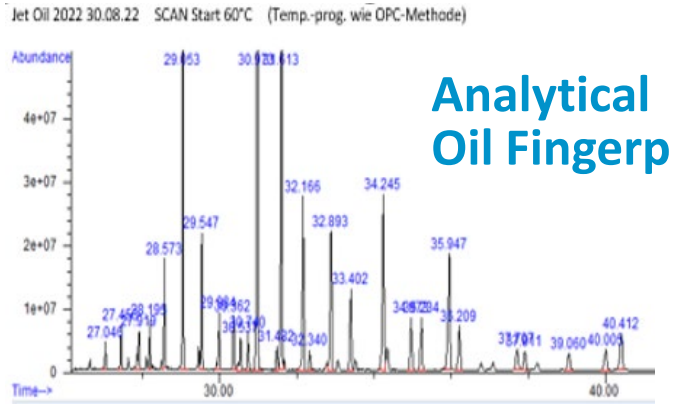
Extensive Analytics

CABIN AIR QUALITY III









Analytical Oil Fingerprint

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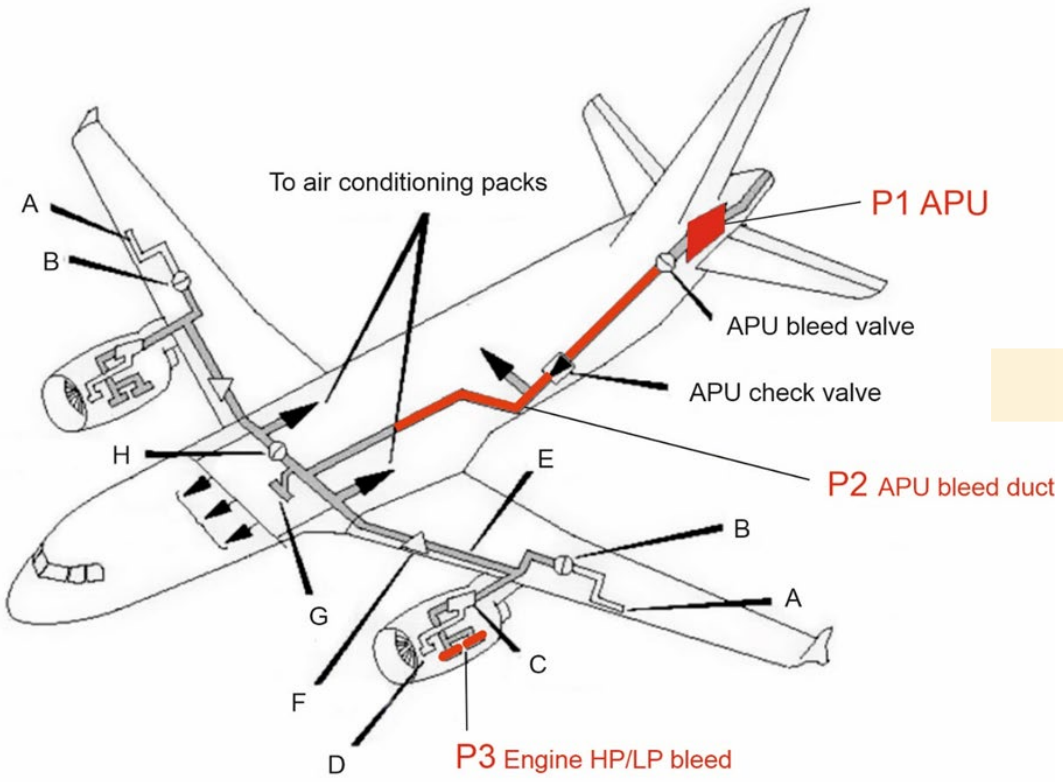
ECS & Duct Sampling – Secondary Event Investigation

LUFTHANSA GROUP

Extensive Analytics

CABIN AIR QUALITY III



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ECS & Duct Sampling – Secondary Event Investigation

About 100 ECS & duct parts from three A320 aircraft:

Part selection and analytical method development in progress

(first results expected at the end of 2023)

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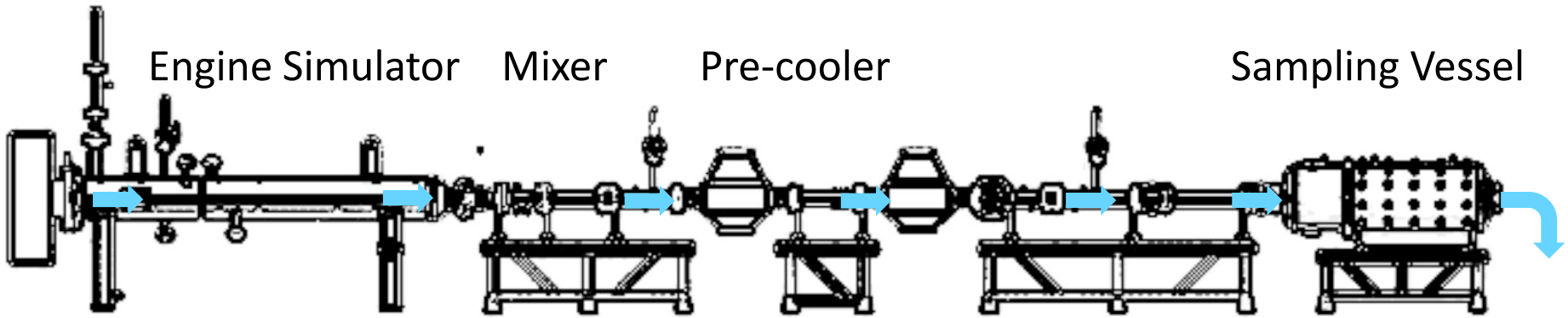
iii) Fume Event Simulation



Fume event

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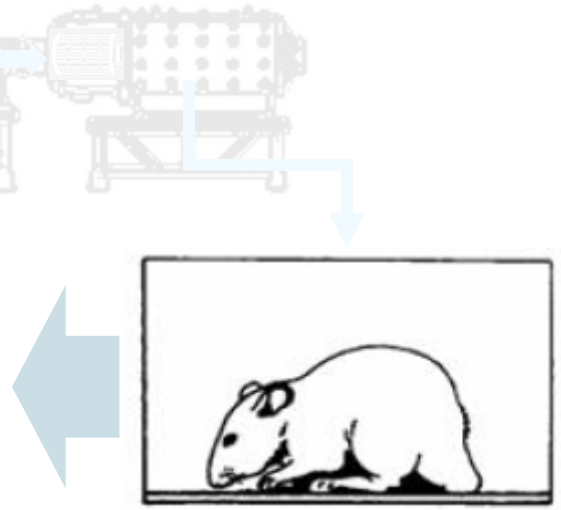
Fume Event Simulation & Toxicity Study

RIVM
Rijksinstituut voor Volksgezondheid en Milieu
Ministerie van Volksgezondheid, Welzijn en Sport

CABIN AIR QUALITY III



Mobile LAB for Animal Tests

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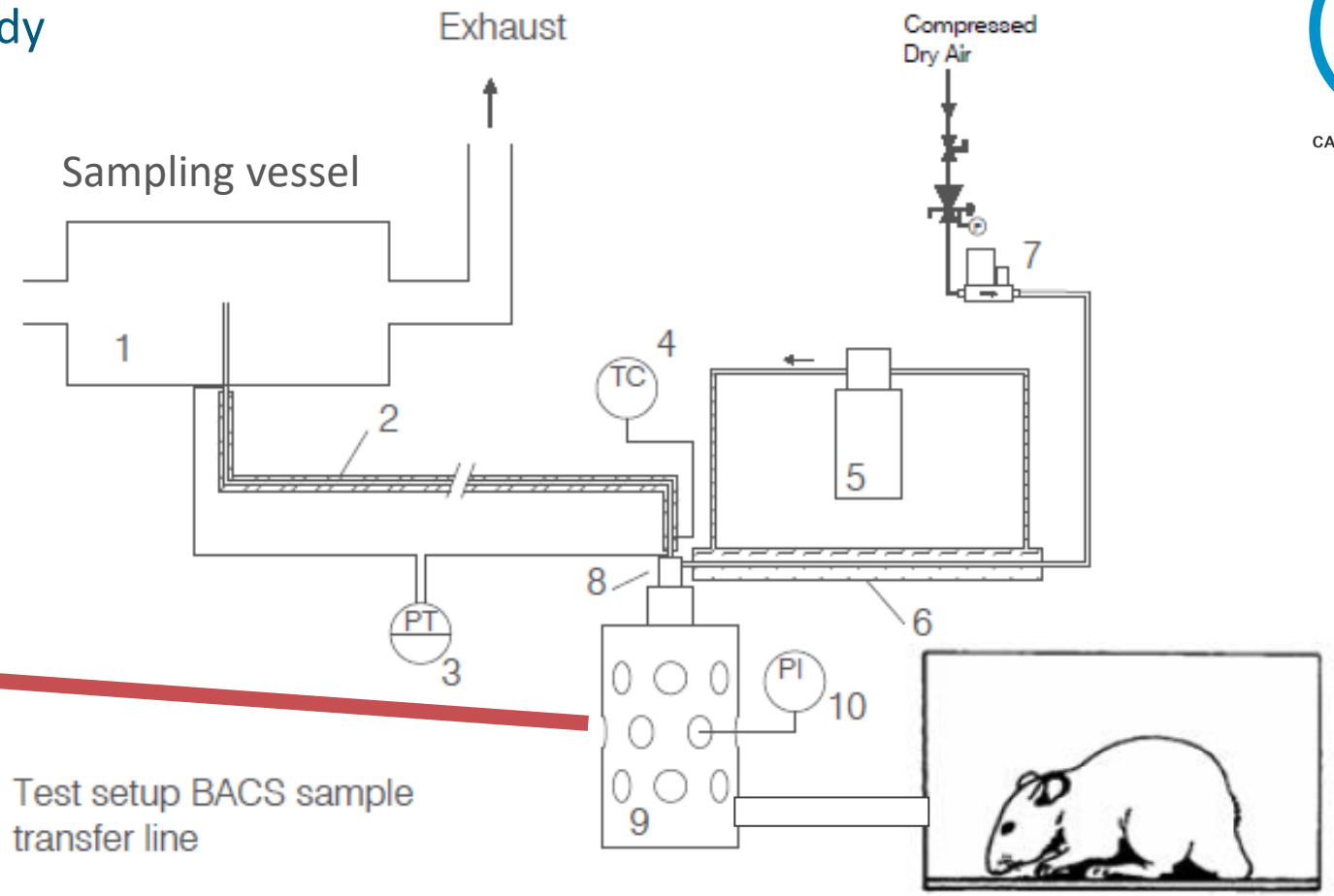
Fume Event Simulation & Toxicity Study



Test setup BACS sample transfer line

Mobile LAB for Animal Tests

CABIN AIR QUALITY III

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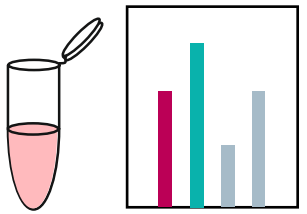
Fume Event Simulation & Toxicity Study

HELMHOLTZ MUNICH

CABIN AIR QUALITY III

GMC German Mouse Clinic

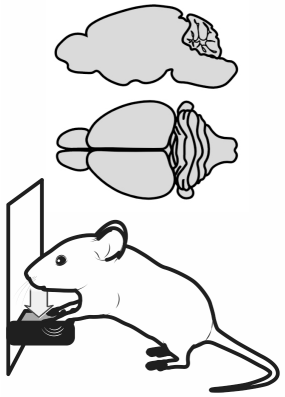
- AChE- and BChE-Assay
- Metabolome Analysis
- Brain hemisphere protein analysis
- Blood markers



Bioanalytics

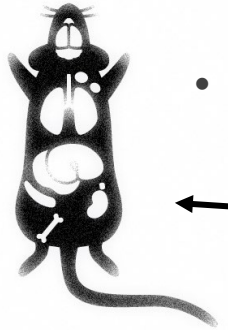
OECD TG 412: sub acute inhalation study

Animal Exposure



Neurotoxicity assessment

- Brain and behaviour analysis at GMC



Dissection

- Brain hemisphere histopathology
- Lung histopathology

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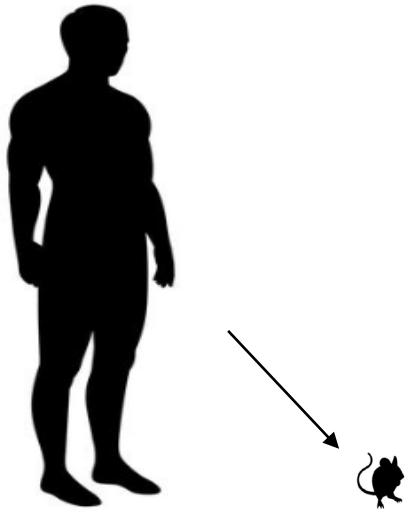
Bioanalytics: Choline-Esterase Assay

InstPharmToxBw

CABIN AIR QUALITY III

- AChE- and BChE-Assay



Assay adaptation required!

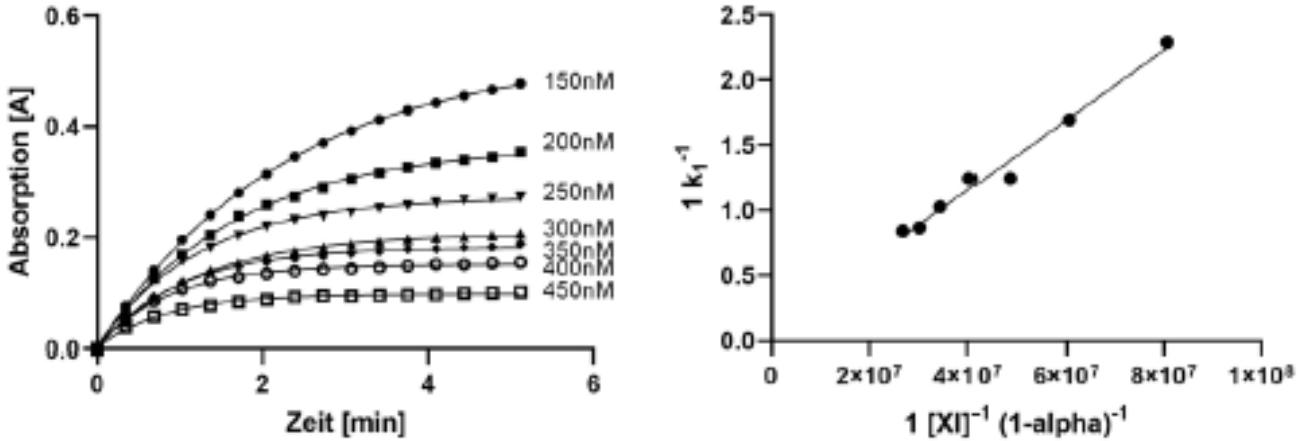


Abbildung 7: Hemmkinetik der humanen BChE durch CBDP. Gezeigt ist die sich verändernde Kinetik bei steigenden Konzentrationen des Organophosphates CBDP von 150 nM bis 450 nM (links). 1 K_i^{-1} wurde gegen 1 $[I]^{-1}$ $(1-\alpha)^{-1}$ aufgetragen (rechts).

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Bioanalytics: Choline-Esterase Assay

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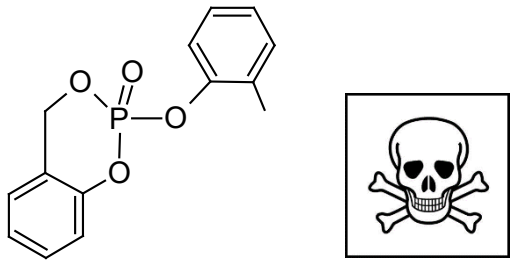
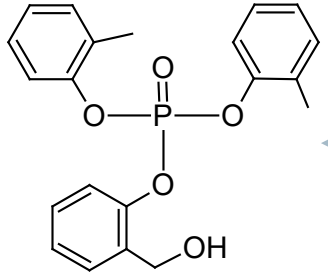
CABIN AIR QUALITY III

- AChE- and BChE-Assay

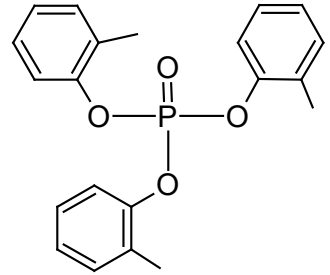


Cresyl saligenin phosphate (CBDP)

- Cresol



Ox



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Bioanalytics: Choline-Esterase Assay

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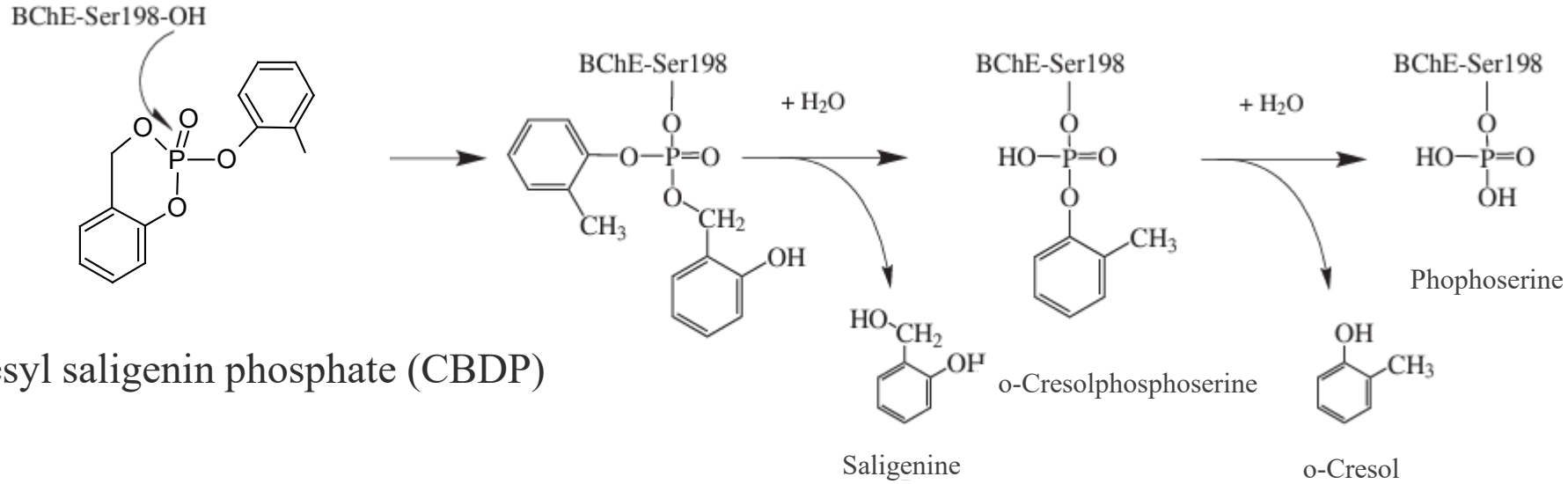
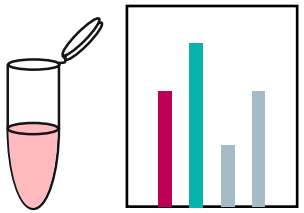
CABIN AIR QUALITY III

- AChE- and BChE-Assay

Organophosphate-Induced
Delayed Neuropathy (OPIDN)



Cresyl saligenin phosphate (CBDP)



Bioanalytics

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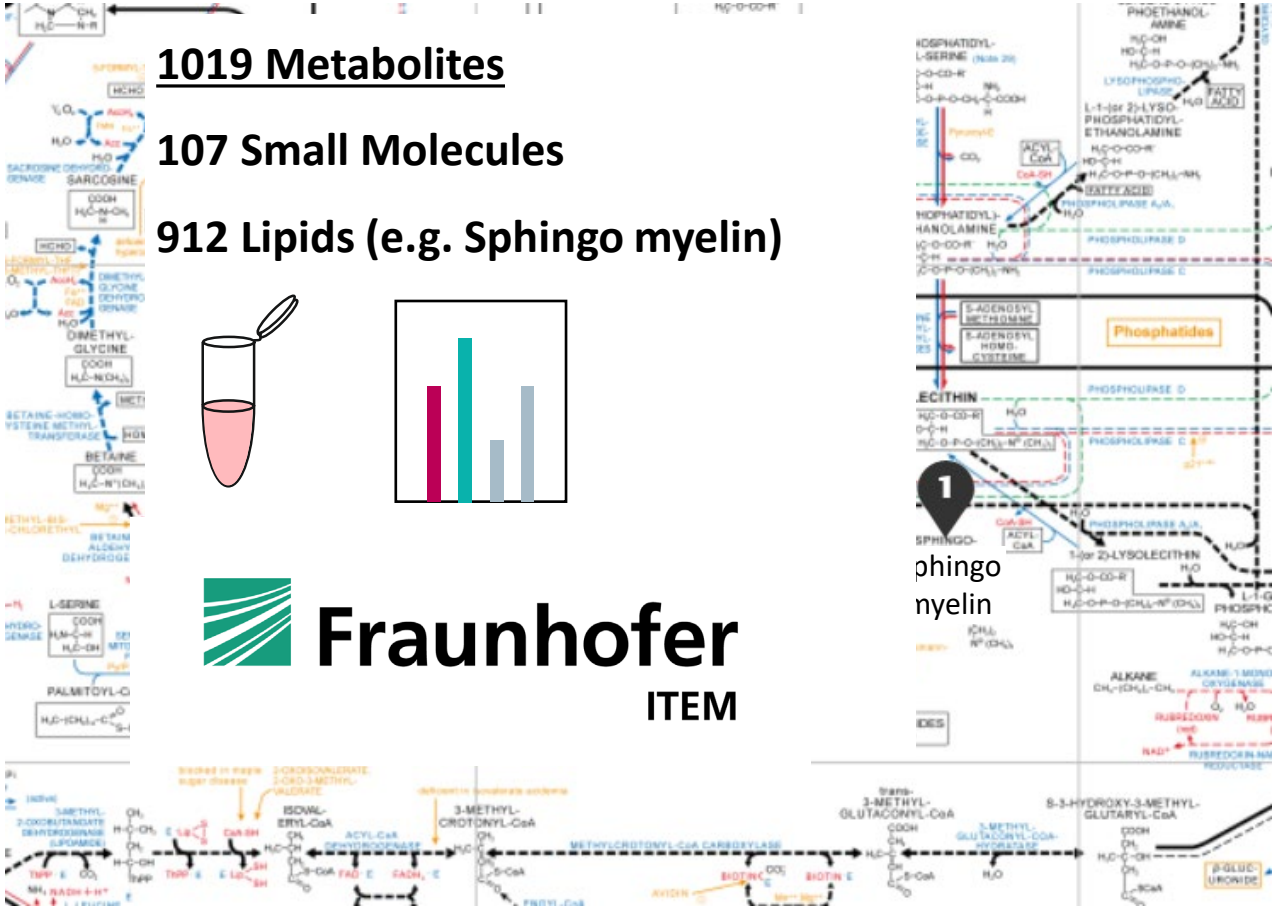
Bioanalytics – Metabolom Analysis

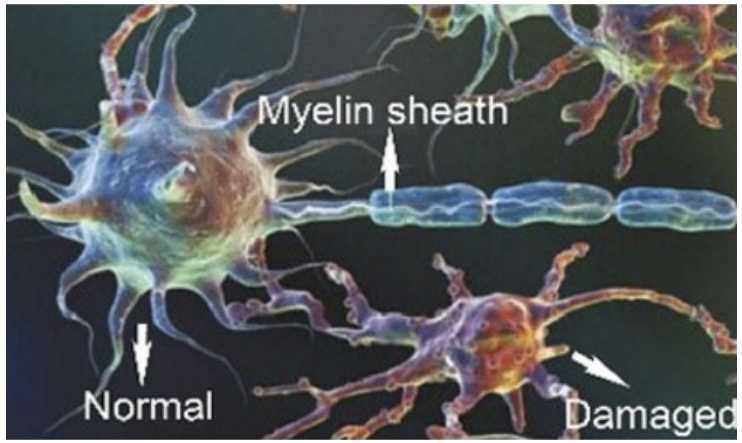
Extensive Analytics

CABIN AIR QUALITY III



Changes in cell wall biochemistry

Organophosphate-Induced Delayed Neuropathy (OPIDN)



Nerve injury: OPIDN (Image by DING Qiang)

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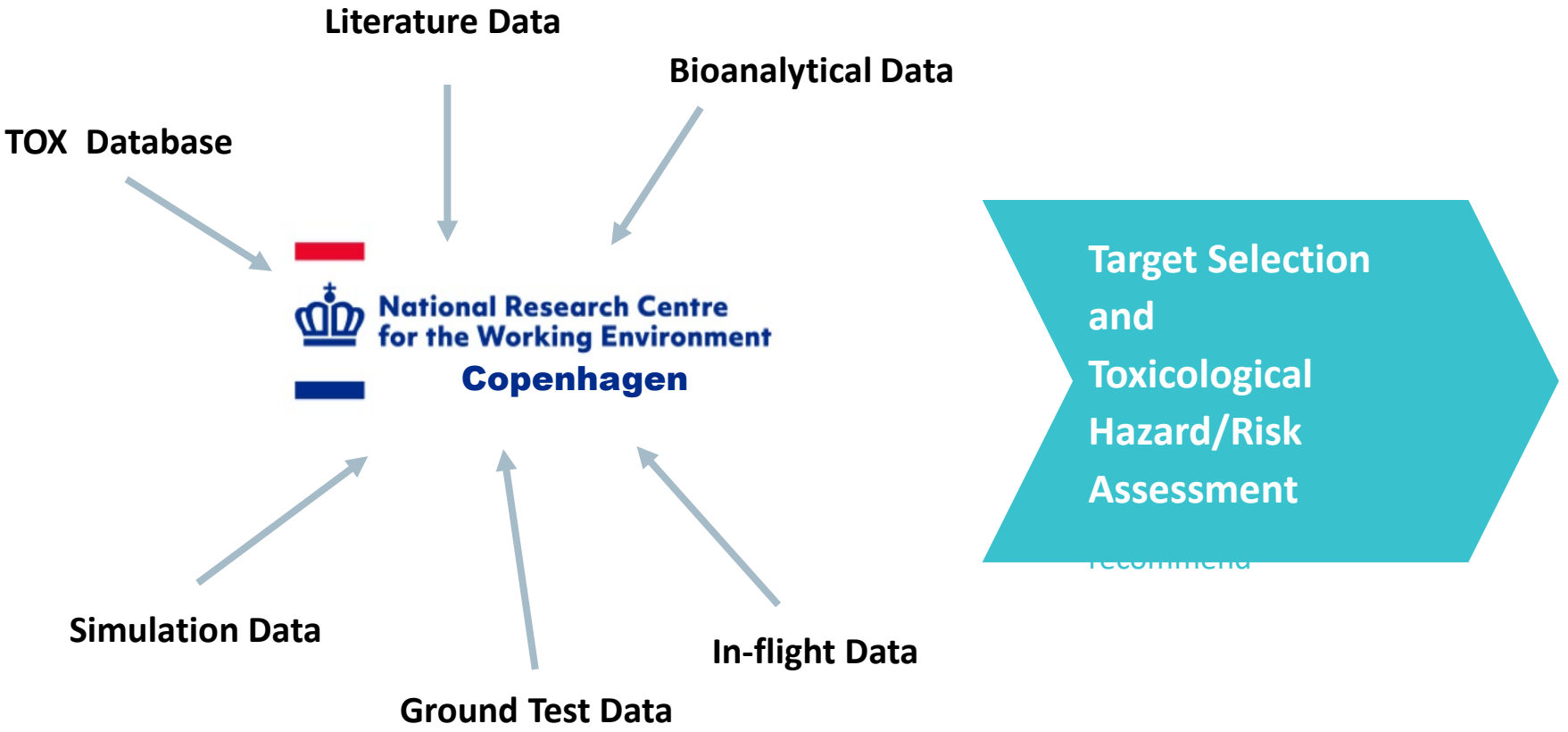
Introduction to the CAQIII project
Toxicological Hazard Assessment

National Research Centre for the Working Environment Copenhagen

CABIN AIR QUALITY III



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Introduction to the CAQIII project
The overarching goal… “Data Generation for Risk Assessment”

CABIN AIR QUALITY III

“The CAQIII project is intended to provide scientific evidence (data) related to the health effects of oil-related fume events.”

RISK = HAZARD x FREQUENCY

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National Research Centre for the Working Environment
Copenhagen

RIVM
Rijksinstituut voor Volksgezondheid en Milieu
Ministerie van Volksgezondheid, Welzijn en Sport

HELMHOLTZ MUNICH

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Thank you for your attention!

GMC German Mouse Clinic

CABIN AIR QUALITY III

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