



EASA
European Aviation Safety Agency

SMOKE & FUMES EVENTS

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TE.GEN.00409-001



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 - Environmental Control System (ECS) Architecture
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- SMOKE & FUMES PROCEDURES FOR CREW
- SMOKE & FUMES OPERATIONAL SCENARIO & EXPOSURE
 - Link with the CAQ III Scenario
- SMOKE & FUMES CONTINUED AIRWORTHINESS PROCESS



DEFINITIONS

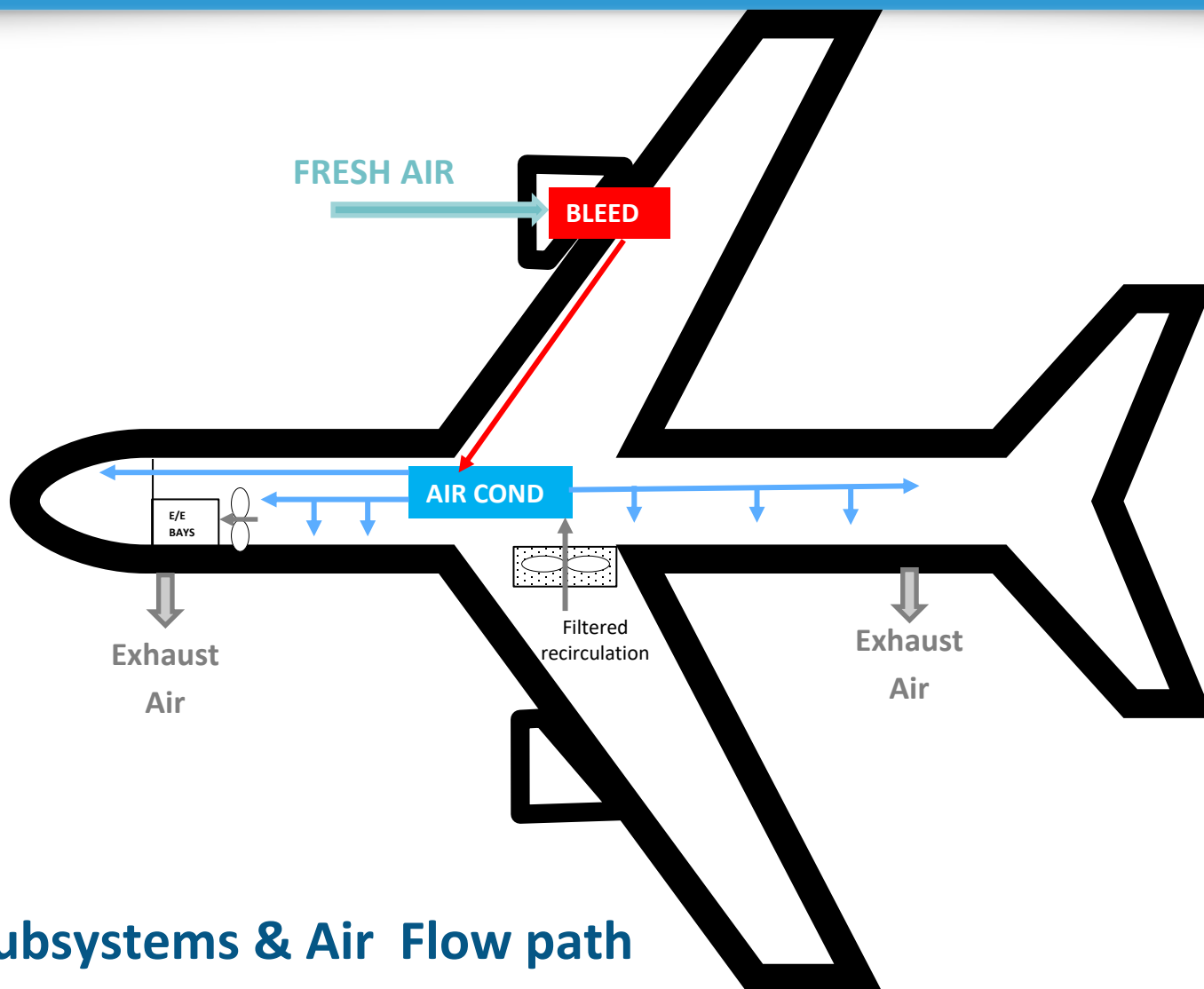
- Definition as per ICAO Circular **CIR 344-AN/202** (Guidelines on Education, Training & Reporting Practices related to Fumes Events) :
 - **SMOKE** : The product of burning materials made visible by the presence of small particles.
 - **FUME(s)** : Odorous, gaseous compounds which are not visible.



- **Environmental Control System (ECS)** : Essential System in charge of :
 - Fresh air supply, ventilation, thermal control and pressurization of occupied (cockpit/cabin) and non occupied (cargo) areas.
 - Avionics bays & electric equipment ventilation (including bays smoke detection)
 - Smoke & fire containment suppression by area ventilation isolation



DEFINITIONS

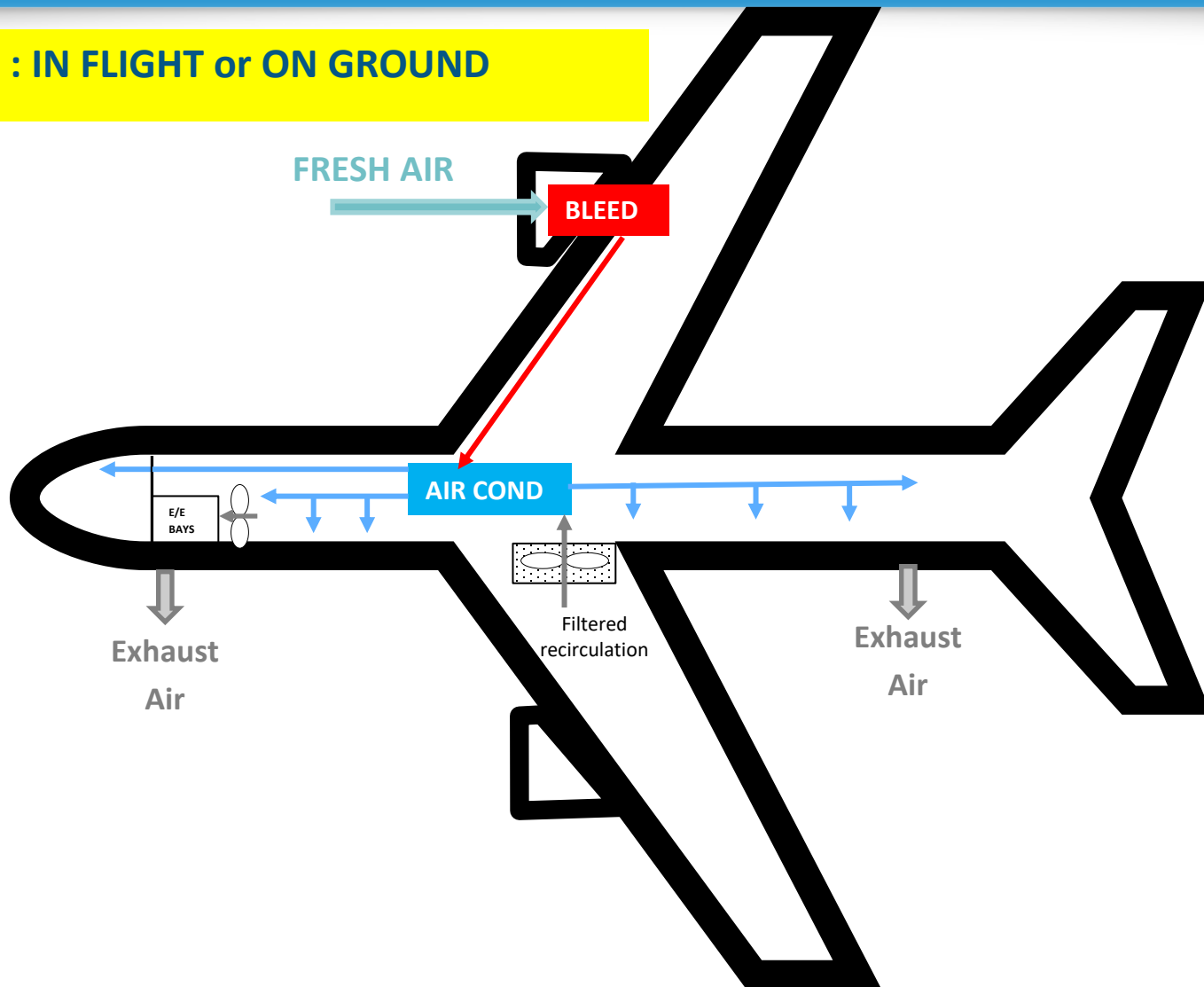


- ECS Subsystems & Air Flow path



FRESH AIR SOURCES

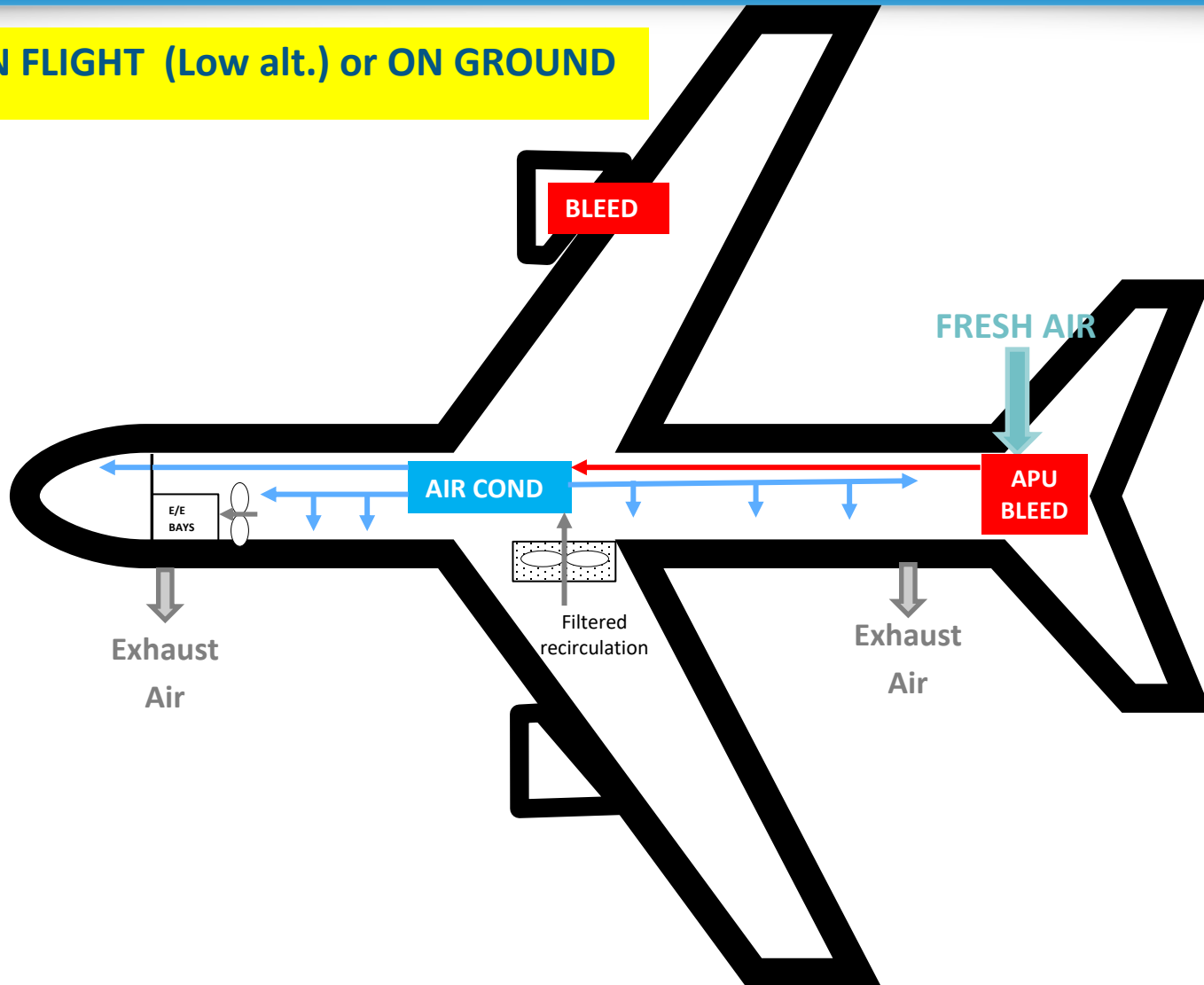
ENGINE : IN FLIGHT or ON GROUND





FRESH AIR SOURCES

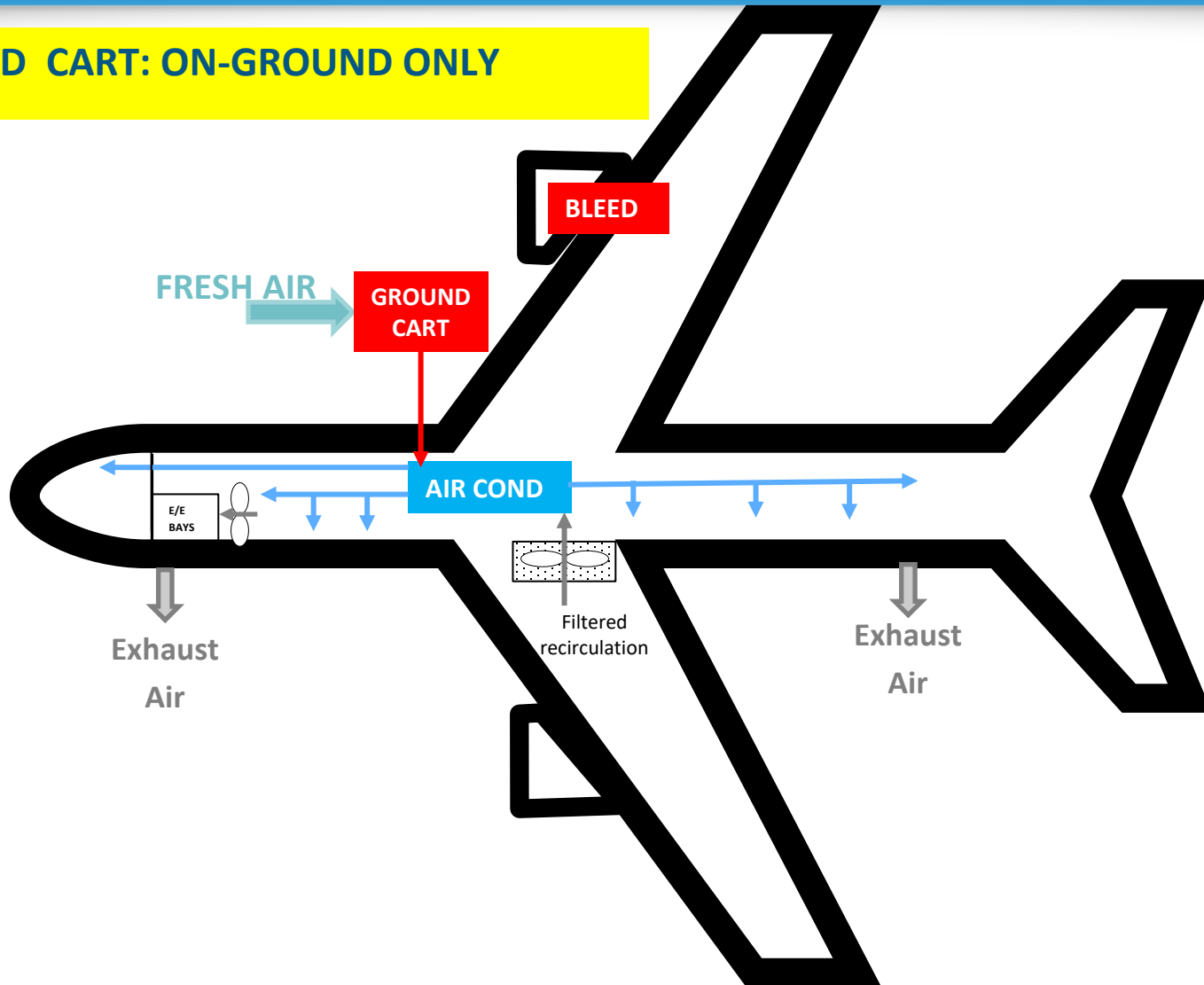
APU : IN FLIGHT (Low alt.) or ON GROUND





FRESH AIR SOURCES

GROUND CART: ON-GROUND ONLY





Cockpit/Cabin air supply might be contaminated by :

▪ **External Sources (Out of the airplane perimeter)**

- On Ground External air quality affected by ground service vehicle exhaust or other airplanes exhaust, de icing/anti-icing fluids (including inadequate procedure)
- Carry-on baggage content spillage / Galley food items
- Cleaning products, disinfectants , insecticides

▪ **Internal Sources (In the airplane perimeter):**

- Engine Exhaust recirculation (On ground)
- Inadequate maintenance (abused engine cranking, Oil tank overfill...)
- Failures of Engines or airplanes systems:
 - APU/Engine oil leakages, Hydraulic System leakages
 - Electrical/electronic equipment overheat
 - Air system failure (Air cond/fan overheat, bearing seizure....)
 - Galley equipment (overheat, ...)
 - Water waste system leakages
 -



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- On Ground External air quality affected by ground service vehicle exhaust or other airplanes exhaust, de icing/anti-icing fluids (including inadequate procedure)
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**Scope of CAQ III research project :
Air contaminated by Engine/APU Oil**

- **Internal Sources** (In the airplane perimeter):

- Engine Exhaust recirculation (On ground)
- Inadequate maintenance (**abnormal engine cranking, Oil tank overfill...**)
- Failures of Engines or airplanes systems:
 - **APU/Engine oil leakages**, Hydraulic System leakages
 - Electrical/electronic equipment overheat
 - Air system failure (Air cond/fan overheat, bearing seizure....)
 - Galley / Cabin equipment (overheat, ...)
 - Water waste system leakages
 -





SMOKE/FUMES PROCEDURE

- The performance of smoke/fumes procedure follows a smoke detection alert or the visual or olfactory perception of smoke/fumes (by cockpit or cabin crew).
- The procedure requires :
 - A quick reaction as a fire might develop quickly
 - Two ways communication between the cockpit and the cabin crew to ease the identification of the smoke/fumes source
- The procedure is structured in 4 blocks of actions
 - Immediate actions
 - “At any time” items
 - Diversion decision
 - Troubleshooting



SMOKE/FUMES PROCEDURE

(1) Immediate actions (quick / simple & reversible)

- Smoke Containment (Switch off the fans)
- Protect the crew (based on pilot decision/threat perception : don the cockpit oxygen mask with 100% O2 supply for smoke/fumes protection)
- Communication between the Cockpit/cabin crew

(2) “At any time” actions

- If smoke/fumes become the greatest threat, Pilots will perform
 - the SMOKE FUMES REMOVAL (ie: depressurize the A/C, open FD window...)
- If situation becomes unmanageable, Pilot shall consider immediate landing



(3) Diversion decision

- Based on the capability to immediately/obviously identify and isolate the smoke/fumes source (ie dedicated system alert or smoke detection means)

(4) Troubleshooting

- After the diversion initiation, perform trouble shooting following a list of probable smoke sources :
 - AVIONICS
 - AIR CONDITIONING
 - CABIN EQUIPEMENT



SMOKE/FUMES PROCEDURE

(3) Diversion decision

- Based on the capability to immediately/obviously identify and isolate the smoke/fumes source (ie dedicated system alert or smoke detection means)

(4) Troubleshooting

- After the diversion initiation, perform trouble shooting following a list of probable smoke sources :

- AVIONICS
- **AIR CONDITIONING**
- CABIN EQUIPEMENT

-Smoke/fume resulting from APU/ENGINE OIL leakages will belong to AIR COND Smoke category

- smoke (if any) will come out of the ventilation outlets

- Smoke/Fumes source will be isolated by switching of the APU Bleed (when applicable) and the air conditioning pack on the leaky engine side



SMOKE/FUMES OPERATION SCENARIO & EXPOSURE

Scenario with different contaminant concentration & exposure time could be divided into 3 categories :

- **L1 – High Concentration** => Smoke is visible with strong unpleasant odors . The Pilot will don their oxygen masks (to prevent physical distress) and will isolate the air conditioning system to isolate the engine contamination source. **Exposure time: few minutes.**
- **L2 – Medium concentration** => Smoke might not be visible but unpleasant odors is perceived. The pilot might don the mask (physical discomfort). Engine contamination source is not immediately identified. **Exposure time: one flight.** Aircraft would not be dispatched without adequate maintenance action.
- **L3 – Low concentration** => light or transient smell/no smell and no noticeable discomfort. **Exposure time : several flights.**



Correlation between the Operational and CAQ III test scenario

- During the previous FACTS project , an oil contamination event had been simulated on an airplane during ground tests (long dry cranking on an engine) : a strong smell/odour was reported by all test participants.
- Based on the comparison of FACTS by-product concentrations measured during the airplane ground test with BACS tests, the oil leakage rate associated with a strong smell detection would be estimated to be below **1 mg of engine oil per m³ of air**.
 - This condition is therefore representative of an exposure with high to medium concentrations.



Correlation between the Operational and CAQ III test scenario

- 1 mg/m³ and above**
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 - **L2 – Medium concentration** => Smoke might not be visible but **unpleasant odors** is perceived. The pilot might don the mask (physical discomfort). Engine contamination source is not immediately identified. **Exposure time: one flight.** Aircraft would not be dispatched without adequate maintenance action
 - **L3 – Low concentration** => light or transient smell/no smell and no noticeable discomfort. **Exposure time : several flights**



Correlation between the Operational and CAQ III test scenario

- 1mg/m³ oil leakage would then correspond to an operational scenario from few minutes (L1) to 1 hour exposure (L2)
- Dose correlation between the operational and CAQ III tests could be estimated

Exposure/Concentration	Operational Smoke/fumes event	CAQ III test
	1mg/m ³	15mg/m ³
Operational event	1 hour	
(CAQ III) Mice Group 1	-	80 hours
(CAQ III) Mice Group 2	-	27 hours
(CAQ III) Mice Group 3	-	8.5 hours

- **CAQ III scenario results in a more severe contaminant dose exposure than operational smoke/fumes events.**



SMOKE/FUMES CONTINUED AIRWORTHINESS PROCESS

- Large Airplane manufacturers monitor SMOKE/FUMES events reported on their fleet
- Indicators (tracking files) are shared & reported to EASA. They cover :
 - The number of events per year and aircraft models
 - The identification of root causes and main aircraft engine/system contributors
 - For each engine/system contributor : the Aircraft Manufacturers define the initiated or to be initiated improvements
 - Physical symptoms/injuries (when applicable) are analyzed to assess & report the safety classification of the events.
- **Status (end of 2023) : No unsafe condition associated with the reported Smoke/Fumes events & trend is identified.**



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Questions ?

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