



ID266

Gas leak detection using acoustics and artificial intelligence

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Air Liquide
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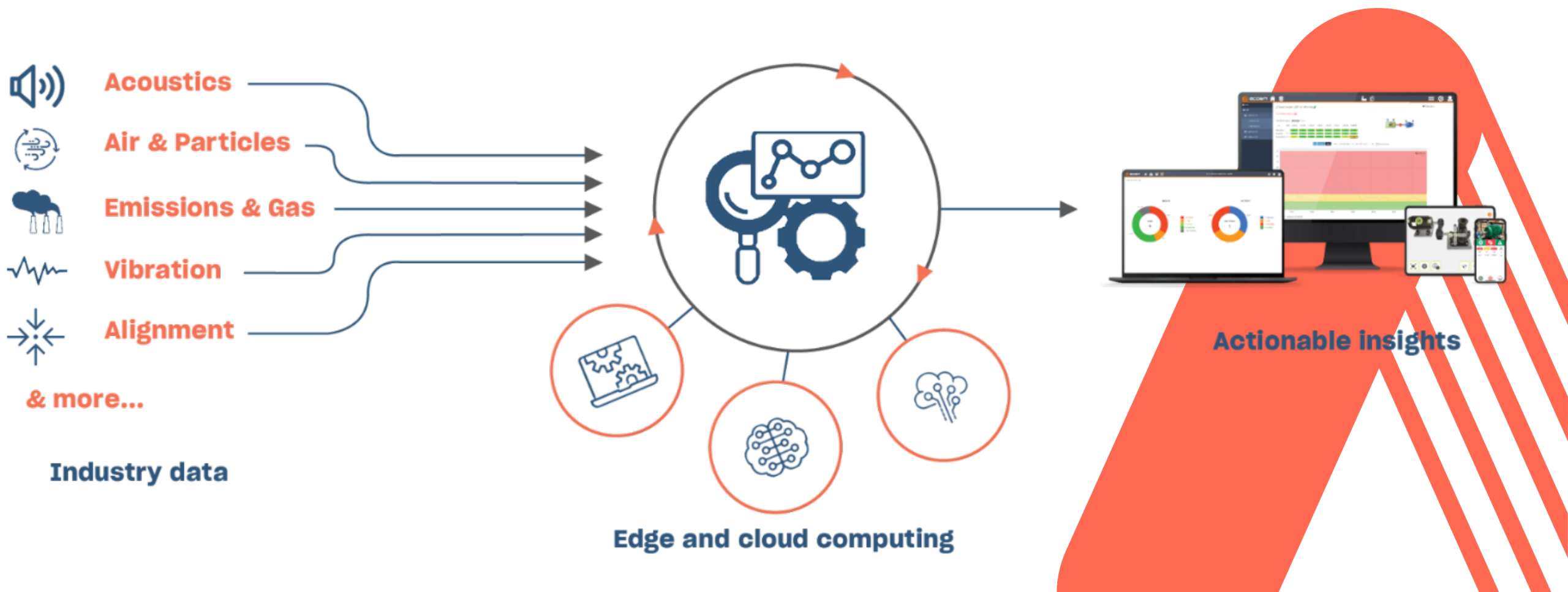


We deliver meaningful data, to take the right decision

Data capture

Turning data into insights

To reach balance



Our mission: provide organisations with better opportunities through focused data and technology

Industrial Reliability

Increasing the productivity of industrials



Emission & process

Achieving environmental compliance



Ambient Monitoring

Preventing & controlling environmental pollution



Protection

Saving lives by protecting soldiers, sites and vehicles

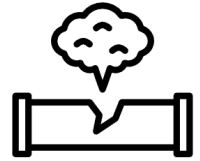


Design

Contributing to effective, robust & noiseless products

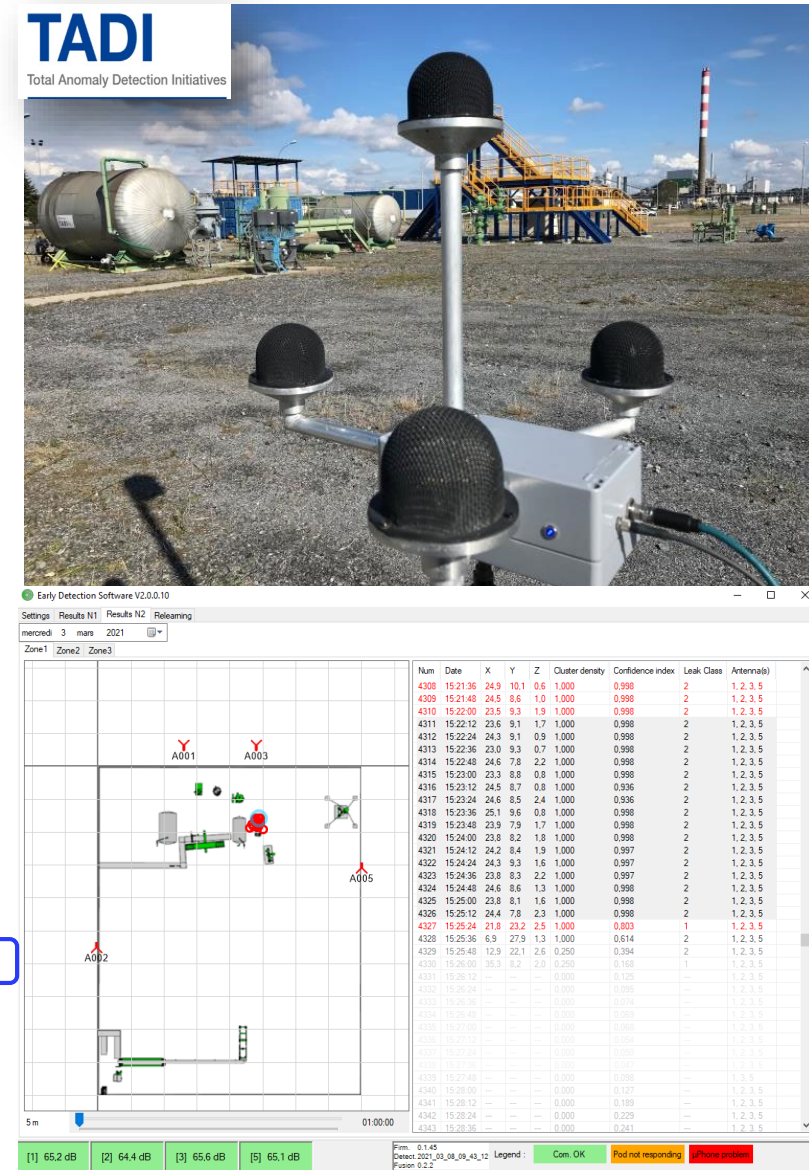


AGLED - Acoustic Gas Leak Early Detection



ACOEM through its brand METRAVIB Engineering is working since 2018 in partnership with TotalEnergies to develop a fixed system for gas leak detection based on **Acoustic monitoring**

- o Autonomous system for early gas leak detection: **any type of gas**
- o Near real-time noise monitoring (every 12 s) using multiple **4-microphone antennas**
- o Detection, localization and classification (3 classes) of gas leaks / multi antenna for a large surveillance zone: management **up to 25 antennas on several zones**
- o System tested on TADI infrastructure (TotalEnergies Anomaly Detection Initiatives) managing more than 5600 gas leaks signals with
 - CH4, CO2, N2
 - Flow rates variation ranging from 0.1 g/s to 300 g/s
 - Exhaust type and diameter: hole, nozzle, flange
 - Distance variation

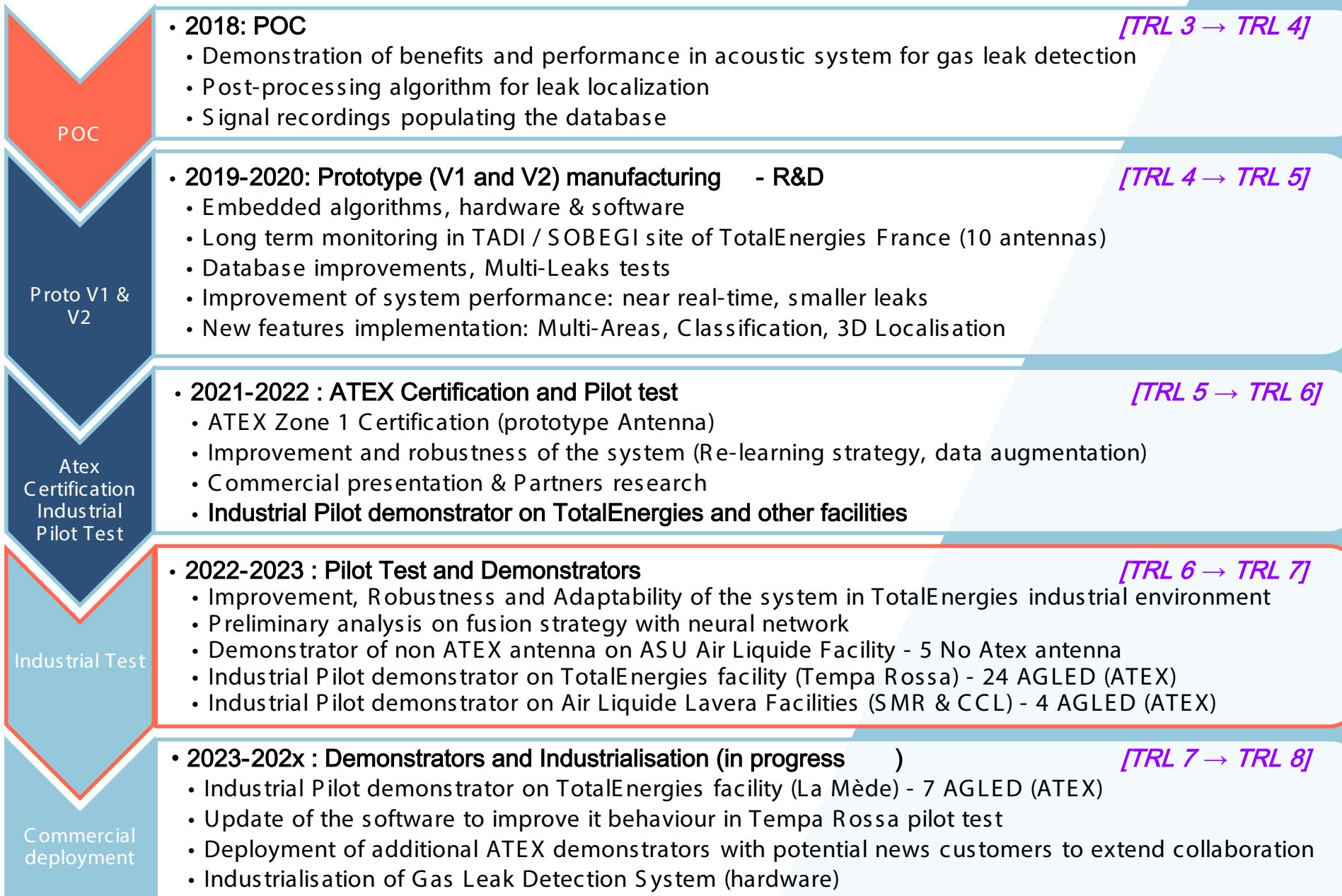


SPL < 60 dB	Very low-noise areas
60 dB < SPL < 70 dB	Low-noise areas
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78 dB < SPL < 85 dB	High-Noise areas
SPL > 85 dB	Too high-noise areas



Collaboration History

* TRL = Technology readiness level

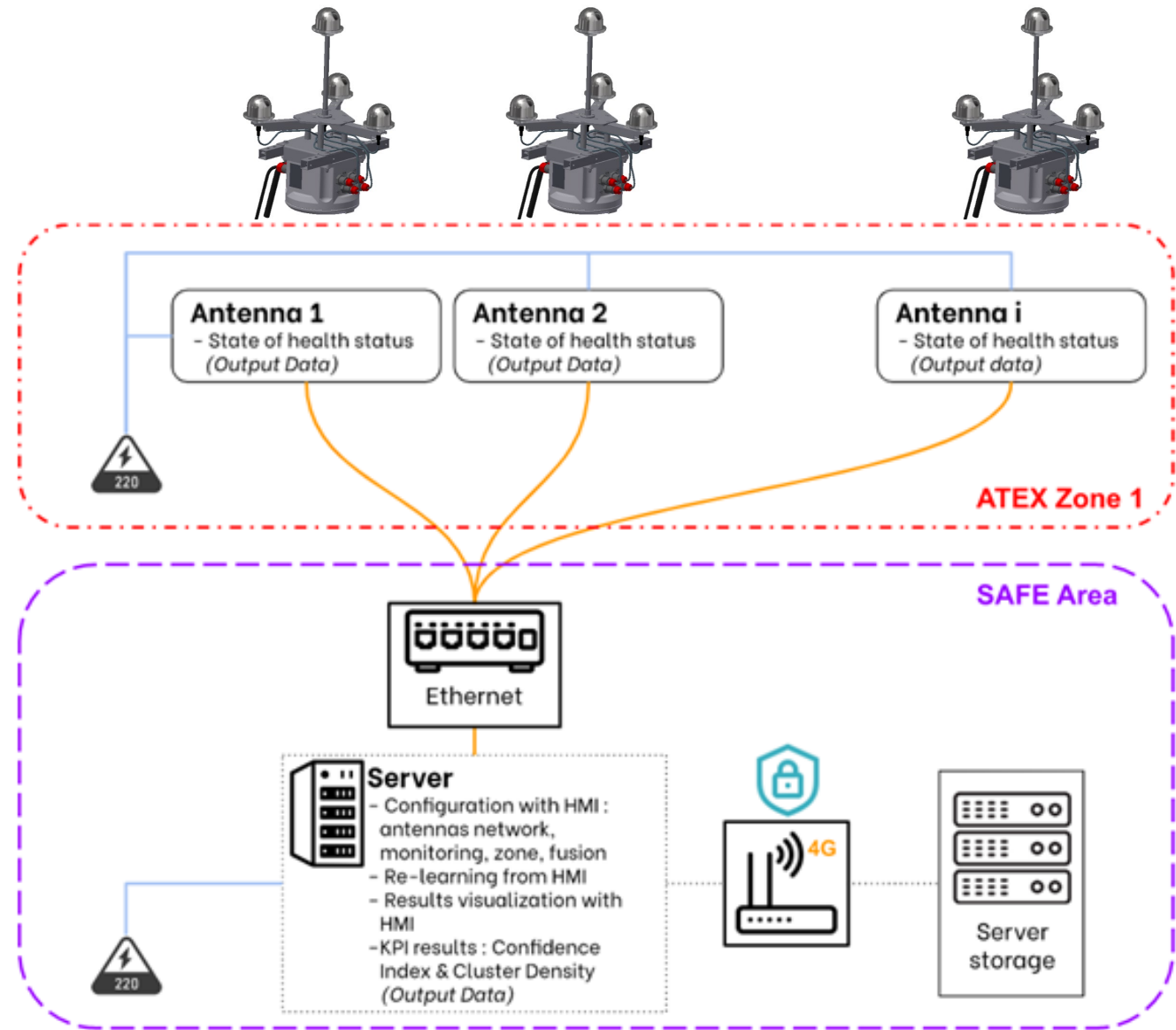


AGLED Architecture



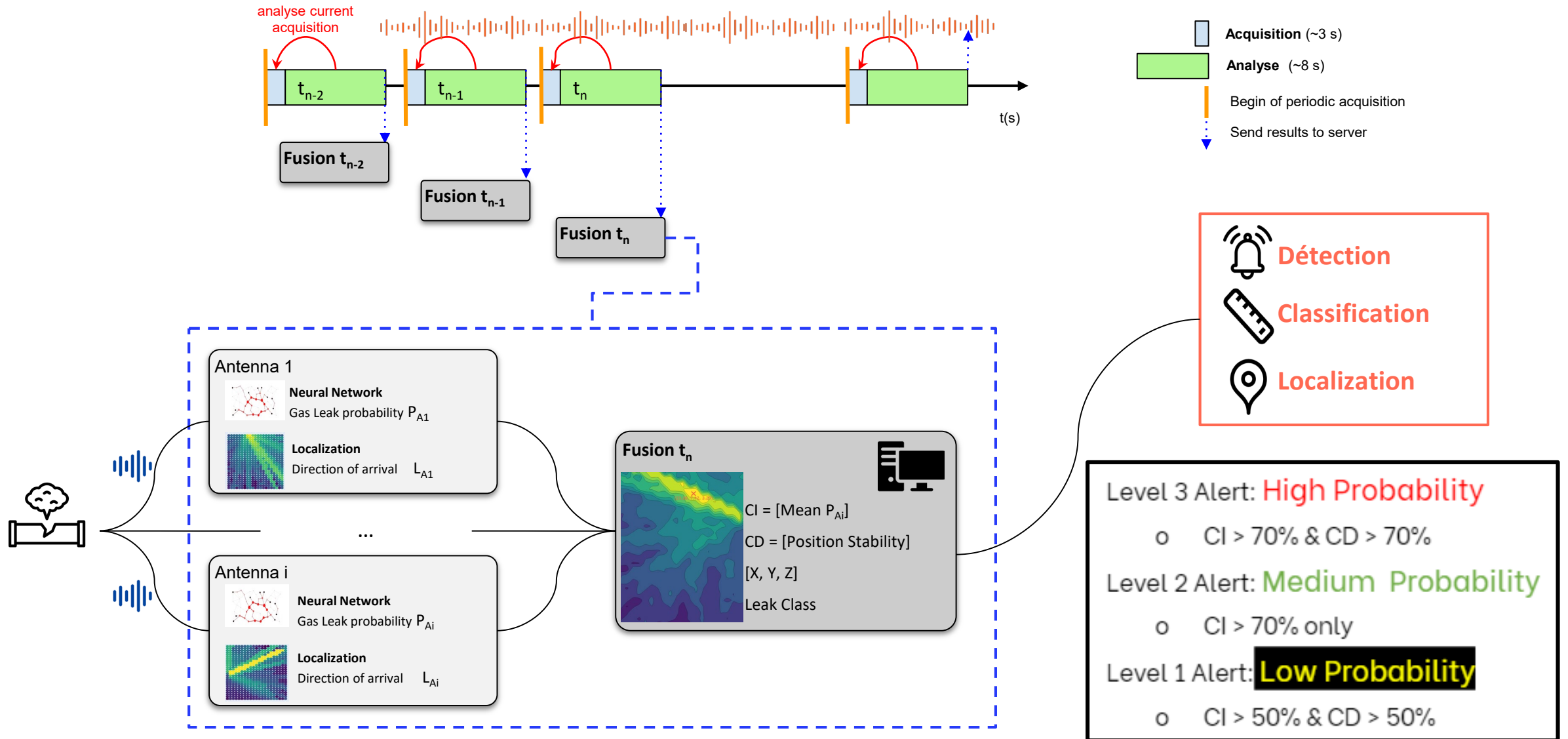
System outputs:

- Sensors **state of health**
- Gas leak probability **Confidence Index CI** (between 0% and 100%)
- Gas leak localization stability index or **Cluster Density CD** (between 0% and 100%)
- **X, Y & Z position** of the identified leakage in a local coordinate system
- Gas leak rate **classification index** (Class 1, 2 or 3)



How it works?

Near real time monitoring with recording and analysis each 12 s

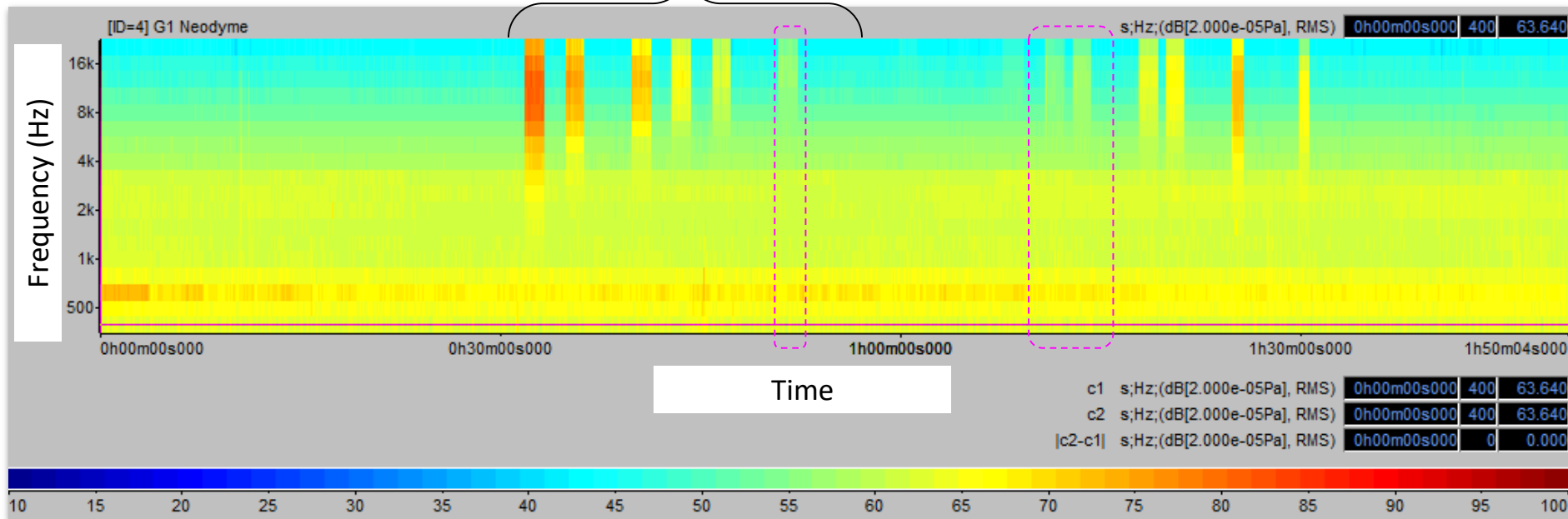


Noise emergence of gas leaks

Acoustic spectrograms in audible frequency range during a test campaign of gas leaks (2 minutes long) show:

- Some differences in the background noise level between antennas in a same site
- Sound of some gas leaks are not detectable because not emerging from the background noise
- Some background noise can be acoustically similar to gas leaks

@ 15 m - N₂ Leakage of [10;7;4;2;1.5;0.7] g/s



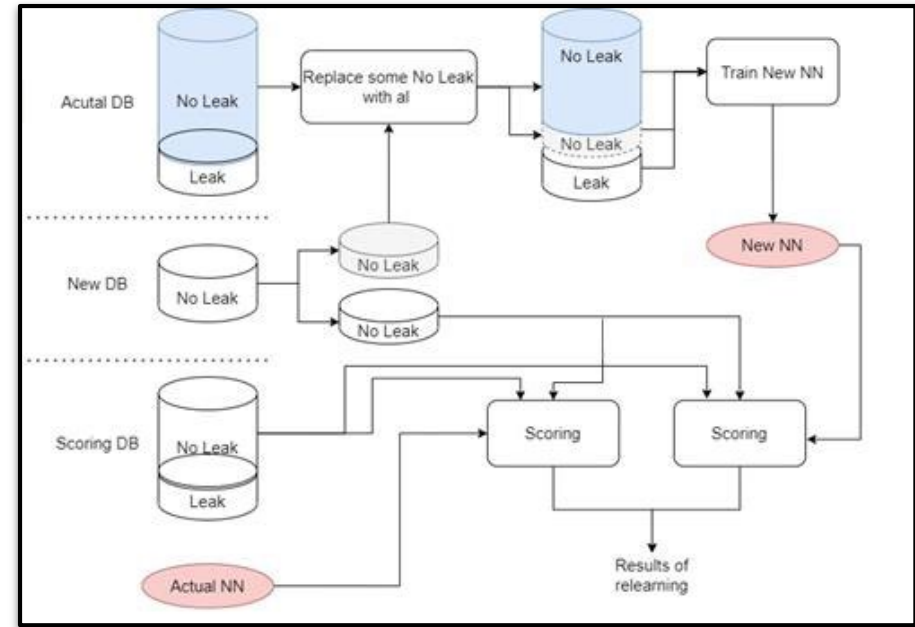
Undetectable gas leaks

Sound Pressure Level (dB)



Relearning Strategy - Database enhancement

- Function to adapt the behavior of the neural network regarding new sound events that could be assimilated to gas leaks. This feature is particularly useful when deploying the system detection on a new site. It enables the system to **learn and integrate into its new sound environment**, while retaining its gas leak detection capabilities.
- **Typical noises** encountered on the production site can be **added to the database** to highly limit false alarms.
- Important to ensure no gas leak while relearning
 - *Can be performed in real-time or with past data*



⇒ **Human validation** of results to ensure

- That data are useful
- There is no regression in the system's capabilities to detect a gas leak

Industrial Test 1 - Context

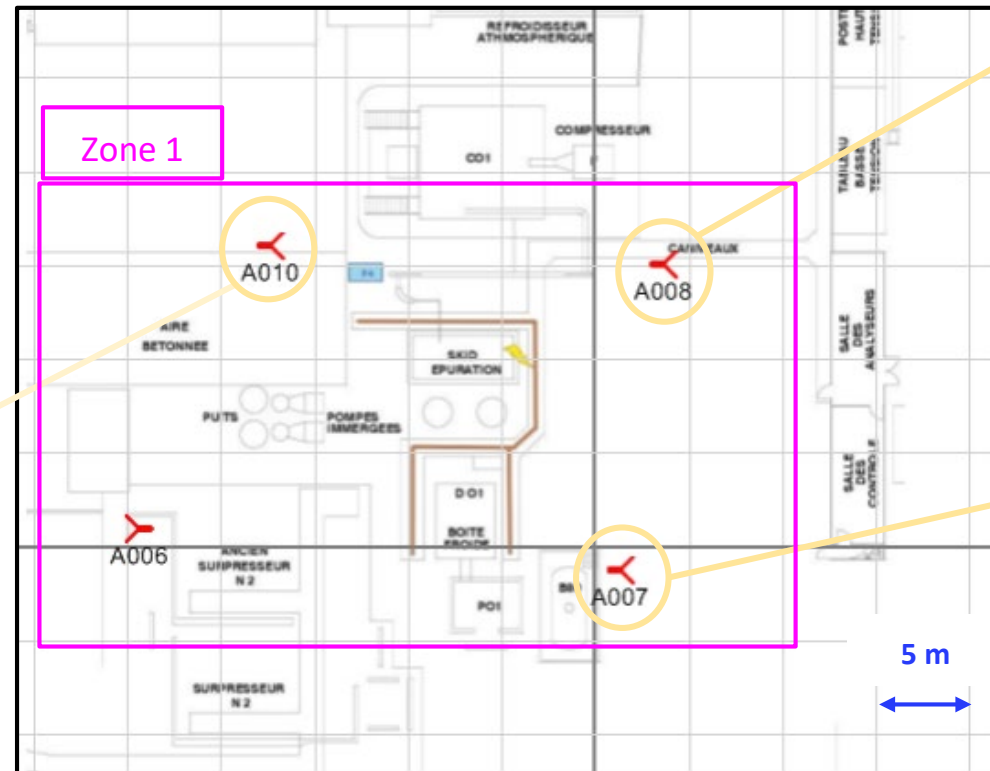
SITE

- N₂, O₂ production site @ Pierrelatte in France
- Max pressure on site of 39 bar
- 4 non-ATEX antennas during 3 months to monitor 1000 m²
 - December 2021 to February 2022
- Moderately congested site
- High-Noise area

MAIN OBJECTIVES

- Adaptation to ambient noise
- Detection sensitivity
- Localization capability

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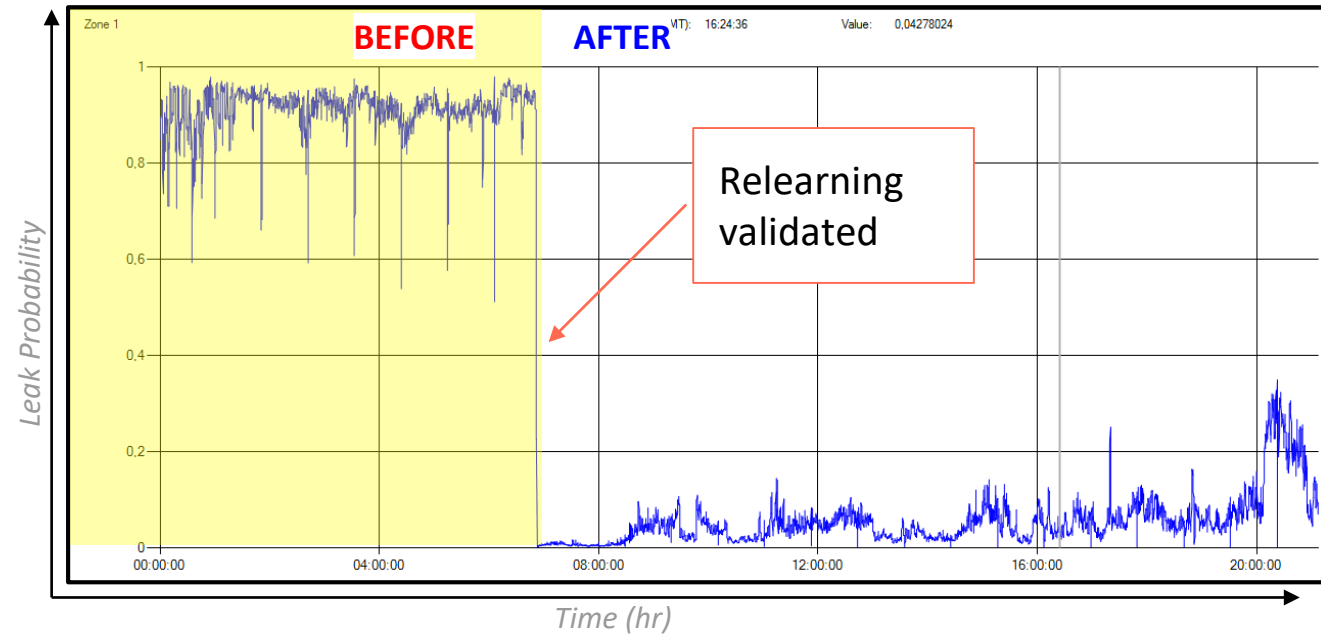


Industrial Test 1 - Results of relearning

- Current Neural Network do not recognize this new soundscape
 - Give a high probability of leakage → relearning needed
 - Almost 5 minutes of relearning are enough for each main ambient noise (process variations)
 - **No degradation of detection capabilities** on its database

⇒ New Neural Network

- Control the false alarm rate
- Still detect class 1 & 2 gas leaks (< 10 g/s)
 - *Threshold to be determined with commissioning*
- Still detect class 3 gas leaks (> 10 g/s)



Leak probability Confidence Index



Industrial Test 2 - Context

SITE

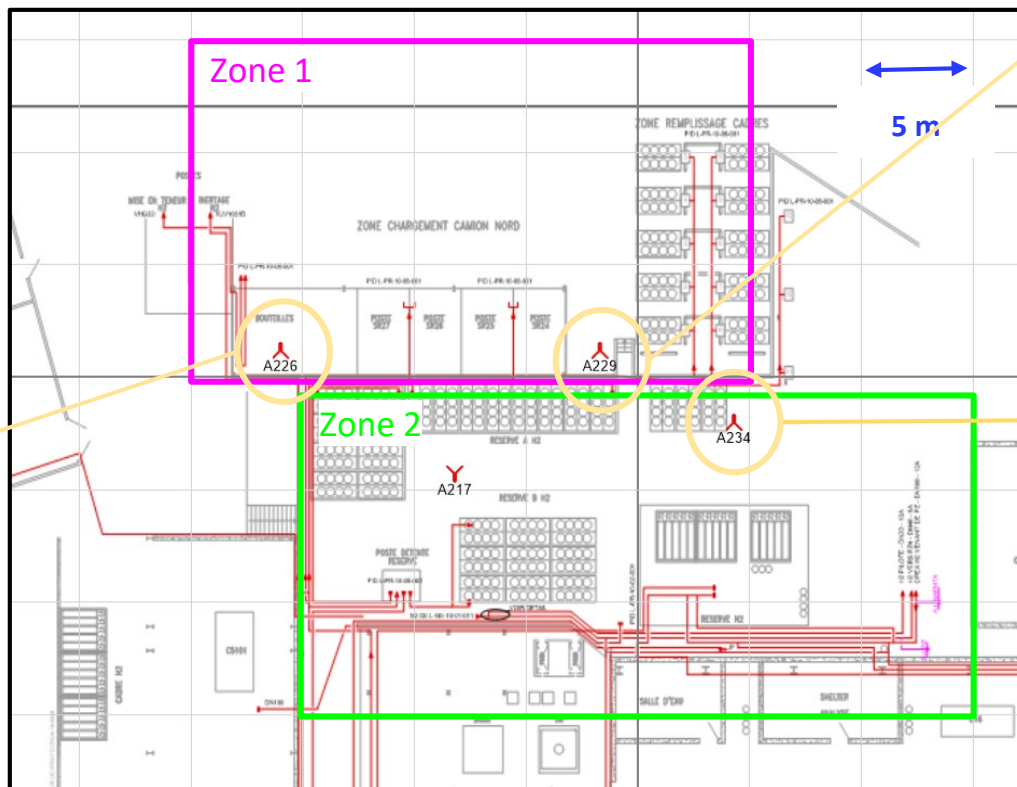
- H₂ Trucks filling center @ Lavera in France
- 4 **certified ATEX** antennas during 3 months to monitor 2 areas of 825 m²
 - January 2023 to March 2023
- Moderately congested site
- Medium-Noise area
 - Noise from fluids in pipes/valves

MAIN OBJECTIVES

- Adaptation to ambient noise
- Detection sensitivity
- Localization capability



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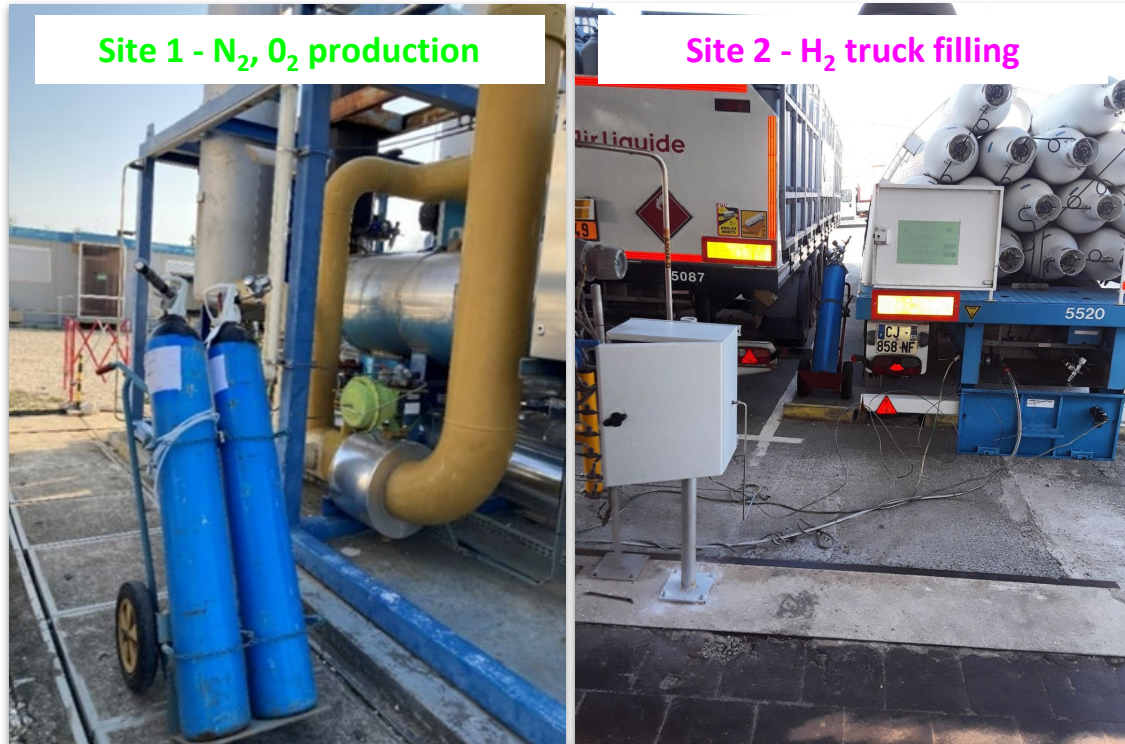


Model: AGLED
 S/N: AF001230-AGLED-xxx
 YEAR: yyyy
 II 2 G
 Ex ib IIC T4 Gb
 INERIS 22ATEX0016X
 -20°C ≤ Tamb ≤ +45°C
 REFER TO USER MANUAL


Acoem France SAS
 200 ch. des Ormeaux
 69578 LIMONEST
 France

Commissioning - Illustration


- Commissioning with N_2 gas leaks using cylinders, pressure regulator and calibrated pierced caps at different locations



Site 2 - Gas leak 4 g/s

 True Leak position



 Fusion result visualization in a 2D map
(each 12 s)



Industrial tests - Overall Results

Item	Industrial Site 1	Industrial site 2
<i>Description</i>	N ₂ , O ₂ production site - 3 month monitoring	H ₂ truck loads filling center - 3 month monitoring
<i>Installation description</i>	Distance between antennas 15 to 25 m	Distance between antennas 10 to 20 m
<i>Soundscape</i>	Constant high noise area	Constant medium noise area
<i>Relearning results</i>	No degradation of detection capabilities ⇒ Adaptation of the system to ambient noise	Slight degradation of detection capabilities ⇒ Adaptation of the system to ambient noise
<i>Behaviour after Relearning</i>	1 day with false alarm (Level 3 Alert) ⇒ Relearning needed	<ul style="list-style-type: none"> ● 4 days offline ● 2 days with false alarm (Level 3 Alert) reported due to important soundscape changes (no operator to confirm) ● Some Detection of gas leak during the beginning of truck loads (normal operation)
<i>Commissioning test results</i>	All the leaks > 4 g/s detected → Depend on distance and site congestion Localization error < 15 m	All the leaks > 2 g/s detected → Lower background noise and lower distance Localization error < 5 m



Compared with existing technologies

Why AGLED?



Passive, Smart & Autonomous

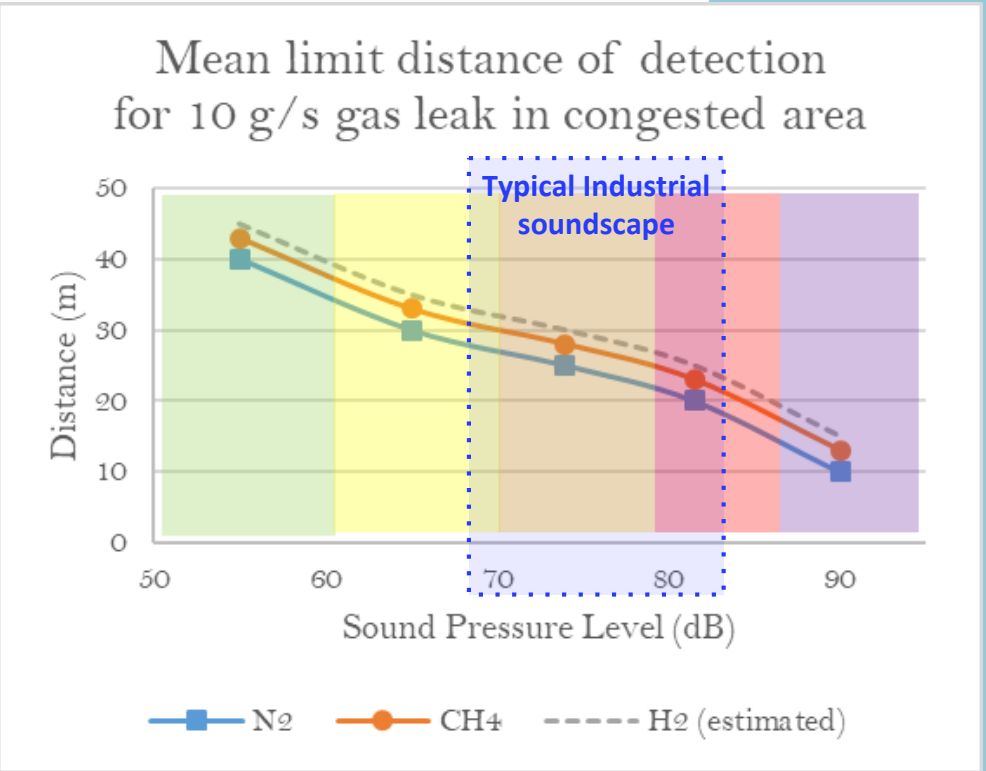
- Non-ultrasonic detection
- Does not work on threshold but on noise type (AI)
- Autonomous, unmanned system with integrated health status for each antenna
- Feedback shows that the system is reliable even on prototypes, with very **little maintenance** (maximum 1 every 2 years)

Leak detection & localization

- After several years of development, leakage detection, localization accuracy and classification capabilities have been improved
- **X,Y,Z localization of gas leak position < 5 m for a 10 g/s gas leak in congested area**

New paradigm using AI

- **False alarm rate under control** thanks to Neural Network relearning strategy
- Complementary to actual systems to detect gas leaks and adapted to any type of gas



Summary & Next steps



- **Detection** limit depends on several factors as soundscape and distance to the equipments to be monitored
 - *Previous engineering study always proposed before installation*
 - *Check of detectability threshold after relearning*
- **Localization** depend on soundscape and congestion
 - *Amount of antennas to be used depends on precision expected*
- Results needs to be consolidated with other **pilote tests**
 - *2 TotalEnergies sites under evaluation with respectively 7 and 24 antennas*
 - *To confirm that False Alarm Rate can be under control*
- **Perform H₂ leakage Tests** and ignited leaks on TotalEnergies site of TADI
- Looking for **partners** for industrialisation and integration into industrial plants



Thank you

Any Questions?

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