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CARES

CITY AIR REMOTE EMISSION SENSING

WP2, Task 2.2 – Deliverable D2.5:

**Final version standalone near real-time plume chase
analysis software**

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Document history and validation

When	Who	Comments
16 th November 2020	Dr Christina SCHMIDT (UHEI & Airyx), Dr Denis Pöhler (UHEI & Airyx)	NOx Real Driving Emissions (RDE) with Plume Chasing. ICAD Online Emission Software v. 2.0 (integrated in ICAD NOx instruments with additional CO2 sensor)
17 th March 2023	Dr James TATE (Uni Leeds)	Prepared formatted deliverable document based on above.
20 th March 2023	Dr Denis Pöhler (UHEI & Airyx)	Update document to new version . ICAD Online Emission Software v. 3.0
20 th March 2023	Ake SJODIN (IVL, CARES project coordinator)	Peer review
23 rd March 2023	Ake SJODIN (IVL, CARES project coordinator)	D2.5: Final version standalone near real-time plume chase analysis software. Submitted deliverable

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Executive Summary

Final version standalone near real-time plume chase analysis software

This deliverable documents the final version (v3.0) of the real-time plume chasing software. The beta version (v1.0) of the software described in Deliverable D2.4 (March 2020) was further developed to simplify the measurements procedure for non-experts and directly provide a classification of the derived emission value (and provide a verdict of the emission value).

The software runs directly on the internal PC of the ICAD plume chasing instrument. CO₂, NO_x and NO₂ concentrations are used together with the GPS data to calculate real time emission data. The interface to the software is via a display (typical tablet) or PC in the cockpit of the plume chasing vehicle. This allows simple application.

Attainment of the Objectives and Explanation of Deviations

Description of work related to deliverables as given in DOW

For the innovative RES technique of plume chasing, currently there is no standardized analysis software and data infrastructure yet. We will refine and automate the software used to attribute plume chasing measurements to an individual vehicle and calculate the fuel-based emissions. The target is to have standalone software to automatically analyse the plume chasing measurements in near real-time, providing the user with a simple, clear emission result, i.e., acceptable / critical / high emitter.

Time deviation from original DoW

Deliverable delivered one-month late (End March 2023) as prepared alongside preparation of Deliverable D2.7 due End of April 2023.

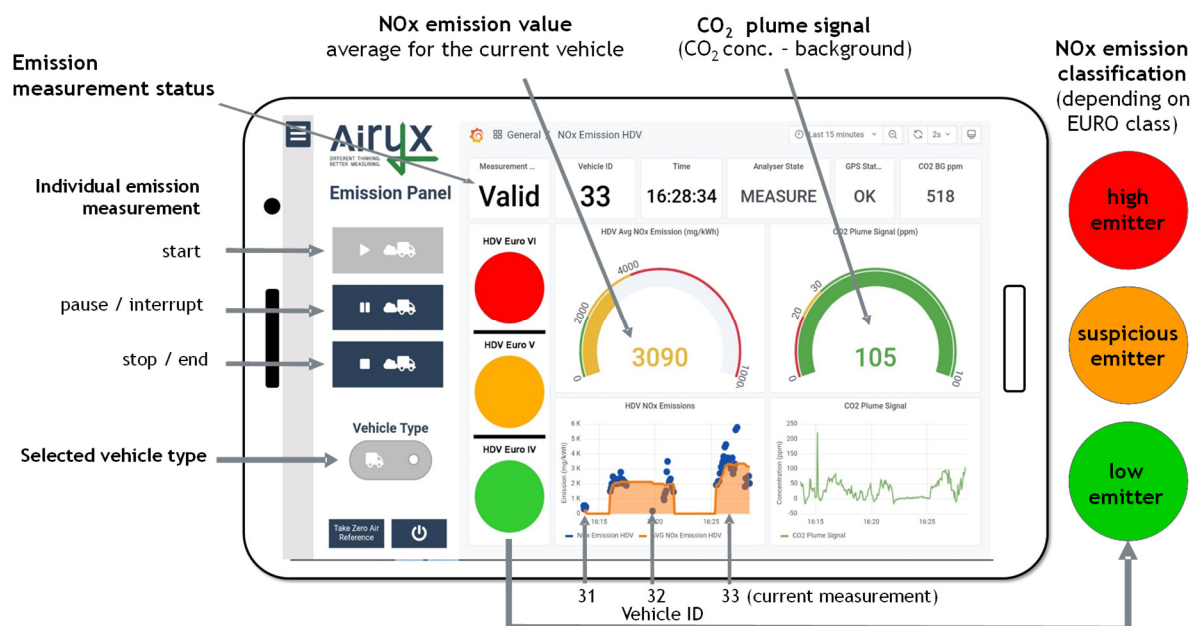
Content deviation from original DoW

None.

Final standalone near real-time plume chasing emission analysis software

The near real-time plume chasing software was developed to simplify the plume chasing measurements and analysis procedure, so accessible to non-experts and directly provide a classification of the derived emission value. A verdict on the emission value and whether a 'chased' vehicle is a candidate 'high emitting' vehicle is automatically provided.

The software runs directly on the internal PC of the ICAD plume chasing instrument. CO₂, NO_x and NO₂ concentrations are used together with the GPS data to calculate real time emission data. The interface to the software is via a display, typically a tablet or PC in the cockpit of the plume chasing vehicle. A screenshot with descriptions is shown below:



Screenshot of plume chasing emission interface (v3.0) and result panel description.

The software calculates the NO_x and NO₂ emission factors measured with the ICAD with a ~2s time resolution. In a first step the concentrations of CO₂, NO_x and NO₂ are corrected by the automatically derived background concentrations from the concentration time series. From the corrected NO_x/CO₂ and NO₂/CO₂ ratios the emission factor for HDV (heavy duty vehicles in mg/kWh) and for LDV (light duty vehicles in mg/km) is calculated. The calculation is fuel based using CO₂ as emission proxy for the generated power (HDV) or CO₂ emission per km (fuel consumption) (LDV).

The new features of v2.0 (2020) and v3.0 (2022) are:

The new interface features an optimised layout with simplified display for easy use also by non-experts with all relevant information.

- **Direct measurement results of individual vehicles.** The software now allows individual start / stop /pause measurement of individual vehicles. The high-resolution emission values will automatically be averaged during the measurement procedure to a more representative average emission value. After stopping the measurement of the individual vehicle, the results will be stored in a result file. Each measurement is given a vehicle ID number. No post processing is further needed.
- **Automatic classification of the emission value (provide a verdict).** The software directly indicates the user the classification of the observed emission in 3 categories low emitter (green) / suspicious emitter (orange) / high emitter (red). The classification is made for EURO VI / V / IV (6, 5, 4 respectively) separately, as different thresholds according to the EURO class are applied.
- **Simplified measurement status.** The interface now directly indicates the operator the status of the individual vehicle measurement. After pressing “Start” first it indicates “ACQUIRING”. The system will wait for valid emission plume signal, what is by default a CO₂ signal of 30ppm above background. If several valid emission data points are recorded in the emission plume (typ. after 10 to 15s) it changes to “PRELIM” and a first emission value and classification is shown by flashing colour lights. If indication show a low emitter (green), the measurement can be stopped. When indication show a suspicious (orange) or high (red) emitter, further data points should be recorded. After typ. 60 to 90s, the display change to “VALID” indicating sufficient measurements for a reliable measurement result. If now still the classification shows a suspicious or high emitter for the according vehicle EURO class, it is very likely that this vehicle is not operating correctly. The measurement is continued until “Stop” is pressed. Results are than saved in the internal data base with the vehicle ID, GPS locations and additional measurement parameters.
- **Online settings of thresholds.** The thresholds for low, suspicious and high emitters can simply be changed by the operator in a setting window. Also, other parameters like minimum data points and CO₂ threshold can be adapted. The settings are protected by an administrator log in to avoid uncontrolled changes.
- **Operation security levels.** A three-level security system was introduced with different log in to avoid errors in operations. Level 1 is viewer only. This only allows to look on data, but not to interact, start or stop measurements. Level 2 is the user who is allowed to perform measurements by pressing start and stop. The user can also download measurement results. Level 3 (administrator) allows to change settings, save configurations. This is to guarantee comparable measurements.
- **Data interface.** A data interface was introduced to export emission result measurements to the most common used authority HDV OBD inspection tool from Wabco-Würth. That means that authorities can import plume chasing results to the same system and data protocol like HDV inspections are performed. It should simplify the documentation work for authorities combining plume chasing with followed HDV inspections of the suspicious and high emitters.

The new software v2.0 could be applied the first time in a HDV high emitter detection study in Denmark in September / October 2020¹. and Belgium November / December 2021. From these experiences and feedback v3.0 was developed and applied in several studies in 2022 including the CARES campaign in Prague in September 2022. It is now the standard software used by European authorities applying plume chasing for high emitter HDV identification.

¹ Pöhler D. 2021. Heavy Duty Vehicle (HDV) NO_x emission measurement with mobile remote sensing (Plume Chasing) and subsequent inspection of high emitters, study performed for Danish Road Traffic Authority. <https://www.fstyr.dk/da/-/media/FSTYR-lister/Publikationer/ReportDenmark2020v101.pdf>