

# NO<sub>x</sub> Ship Emission Measurements with the ICAD system

- Remote measurement of NO<sub>x</sub> emission factors (mg/kWh) for single ships
- Fast and simple measurement set-up, robust and precise instrumentation
- Direct measurements of NO<sub>x</sub> and CO<sub>2</sub> stationary near water ways (on bridges, shore lines) or on mobile platforms (e.g., chasing vessels)

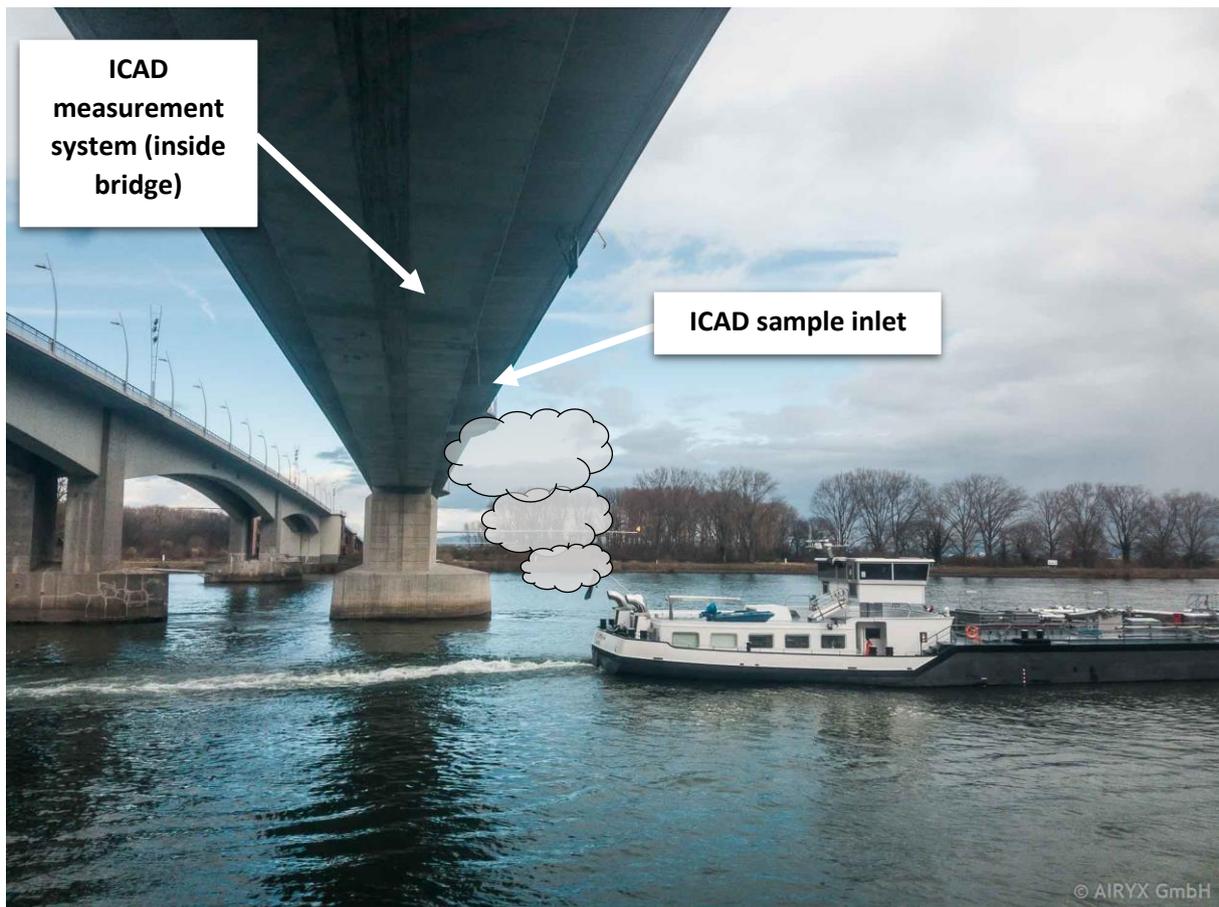


Figure 1: Measurement of ship emission with ICAD. The ICAD instrument is placed inside the bridge above the water way. The sampling line is placed above the water way to measure emission plumes by ships passing below.

By providing high precision NO<sub>x</sub> measurements at high time resolution of several seconds and featuring an optional internal CO<sub>2</sub> sensor, the ICAD system (Figure 2) can be applied to measure ship emission factors when set up near a water way. Due to its robust instrumentation (IP64 version available), low power and low requirements for calibration it is the perfect tool for field applications at waterlines. The system can measure NO<sub>x</sub> and CO<sub>2</sub> of emission plumes emitted by nearby

ships. Since this relies on transport by local meteorology, the location has to be chosen with respect to the prevailing wind direction. Possible locations can be the shoreline of a river, the landing platform in a harbour or at a bridge crossing a water way as shown Figure 1.



Figure 2: ICAD rack (left) and mobile version with sealed housing (right).

The assignment of measured emission plumes to specific vessels is done by the detection of CO<sub>2</sub> enhancements (since all ships with combustion engines emit CO<sub>2</sub> but not necessarily significant NO<sub>x</sub>), with respect to the background concentration (shown in Figure 1: Measurement of ship emission with ICAD. The ICAD instrument is placed inside the bridge above the water way. The sampling line is placed above the water way to measure emission plumes by ships passing below. Figure 3). Combining the ICAD data with a local AIS receiver (which can provide ship information such as location, velocity, size) enables the assignment of emission factors to specific vessels at high frequent water ways.

Besides stationary application, the ICAD system can also be operated on mobile platforms (12V power supply), e.g., law enforcement vessels, to chase target ships and measure NO<sub>x</sub> emission factors on the fly, similar to the so called “plume chasing” method, currently applied to measure on road emissions of light- and heavy-duty vehicles (see <https://airyx.de/item/real-driving-emissions/>).

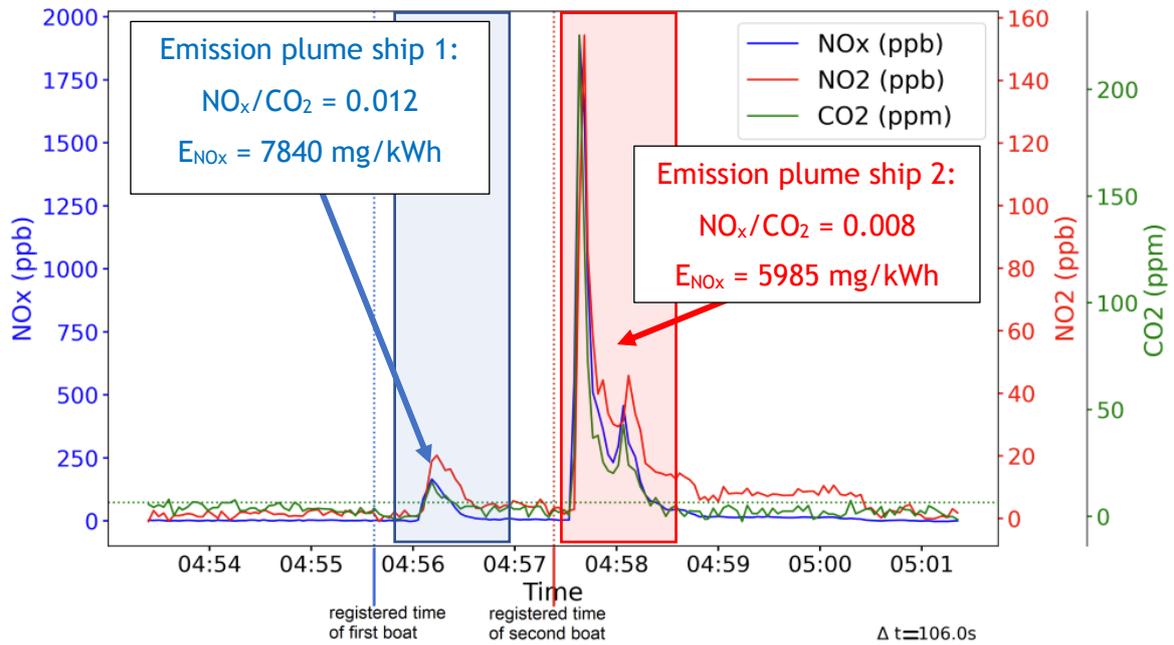


Figure 3: Exemplary measurement of two passing ships showing synchronous peaks of NO<sub>x</sub> (blue line), NO<sub>2</sub> (red line) and CO<sub>2</sub> (excess with respect to atmospheric background, black line) measured by the ICAD instrument. The horizontal line represents a threshold for identification of a valid ship pass, the vertical lines indicate the time of the ship pass taken from AIS data.