DEVELOPMENT OF A MOBILE ENVIRONMENTAL SENSORY UNIT PROTOTYPE

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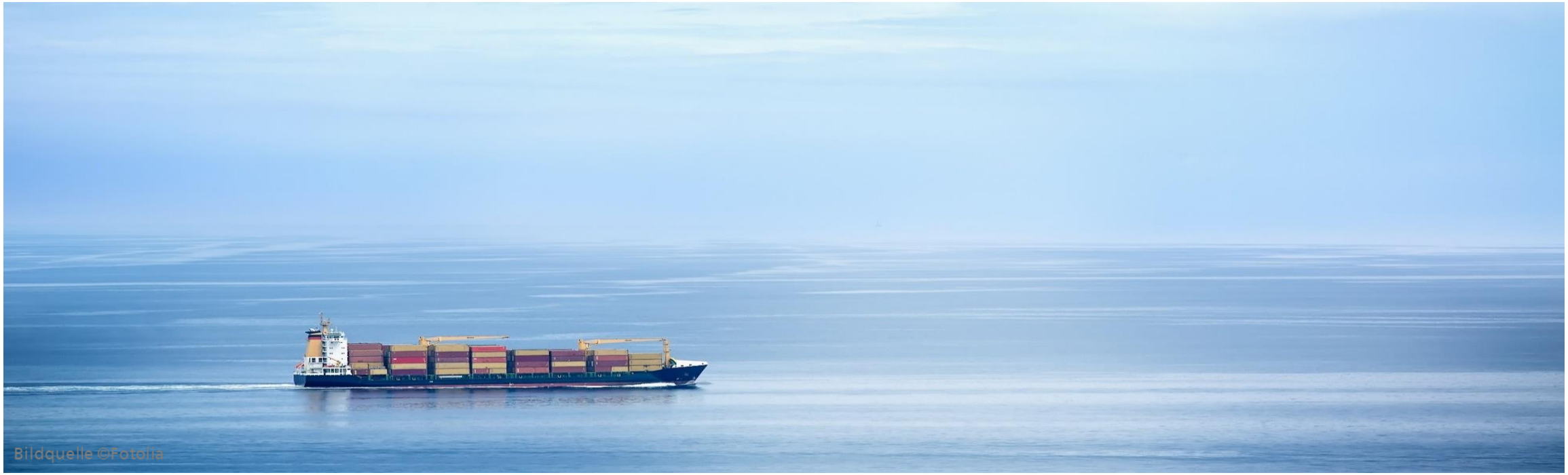

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Motivation
Background

Problem Description

- Shipping emits 2.5% of all GHG with most of them occurring in coastal areas
- IMO and EU regulations such as MAPROL Annex VI and EU-MRV require ships to regulate their emissions
- Measuring, monitoring & abating ship emissions in ports is difficult as timely fluctuations are high due to ship traffic

Idea

- Combining dynamically acquired environmental data with ship positions from AIS data
  - Allows analyzing the pockets of higher concentration, or
  - Influence of entities or gradients of emission throughout the day in a pre-set area when subjected to maritime traffic;
  - Enables determining the influence of single or multiple ships over measurements in a defined space

Solution

- <u>Development of a low budget, low-power sensor platform permanently connected to shore</u>

Design objectives

Proof-Of-Concept Project

- Objectives
  - Rainproof unit measuring environmental gases
  - Compatibility with on-board AIS Transceiver
  - TRL 5 aimed
  - Correlation of sensor values with actual own-ship position
  - Synchronisation of traffic-ships in a defined radius
  - Post-processing of the 2 datasets into a web-based application for visualisation

- Proof-Of-Concept project includes
  1. Developments of mobile environmental sensory unit (ESU) prototype
  2. Develop web-based data visualisation software (WebUI)
  3. Establish infrastructure for real time on-board to shore data transmission

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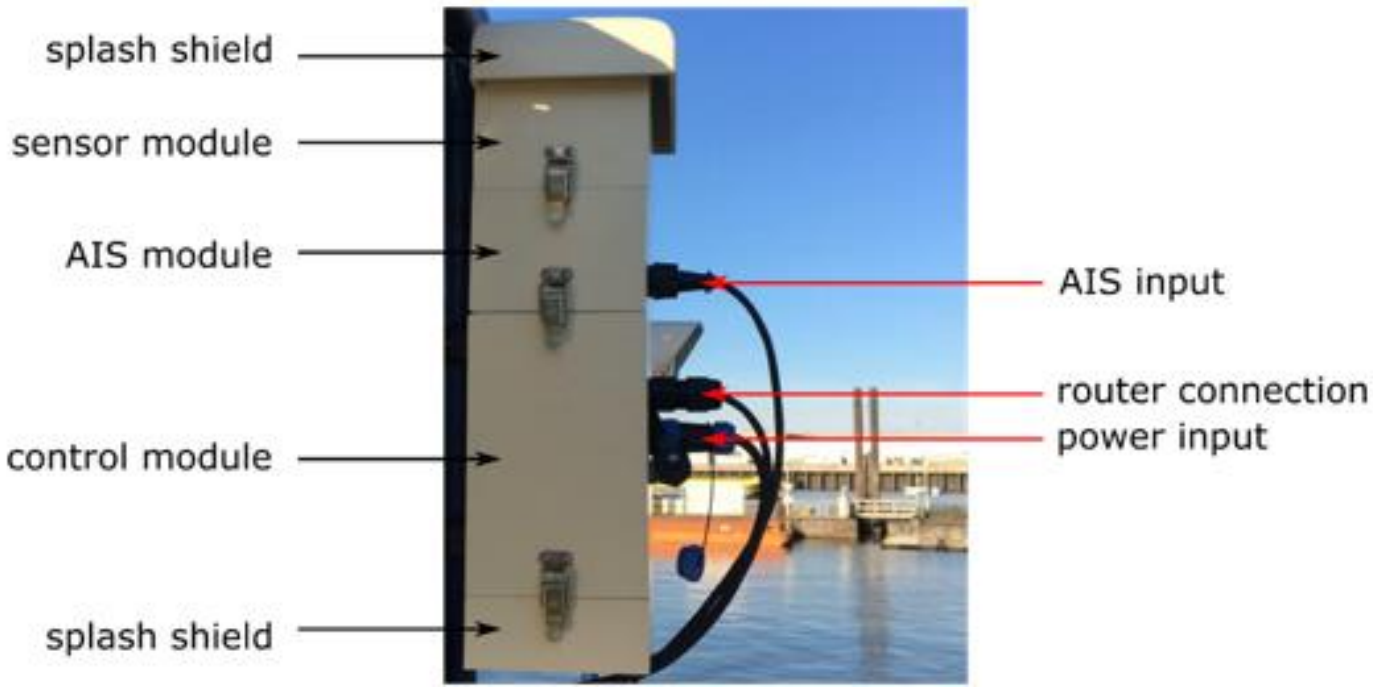
Technical Implementation

ESU: Hardware Assembly



Features

- Modular & Scalable
- Low budget & Low-power
- Samples controlled air volume
- Rain proof

Components

- Arduino, Raspberry Pi
- Electrochemical low-cost sensors
  - Calibrated: Altitude, Humidity, Temperature, Pressure
  - Not calibrated: NO_2, PM_{10}, $PM_{2.5}$

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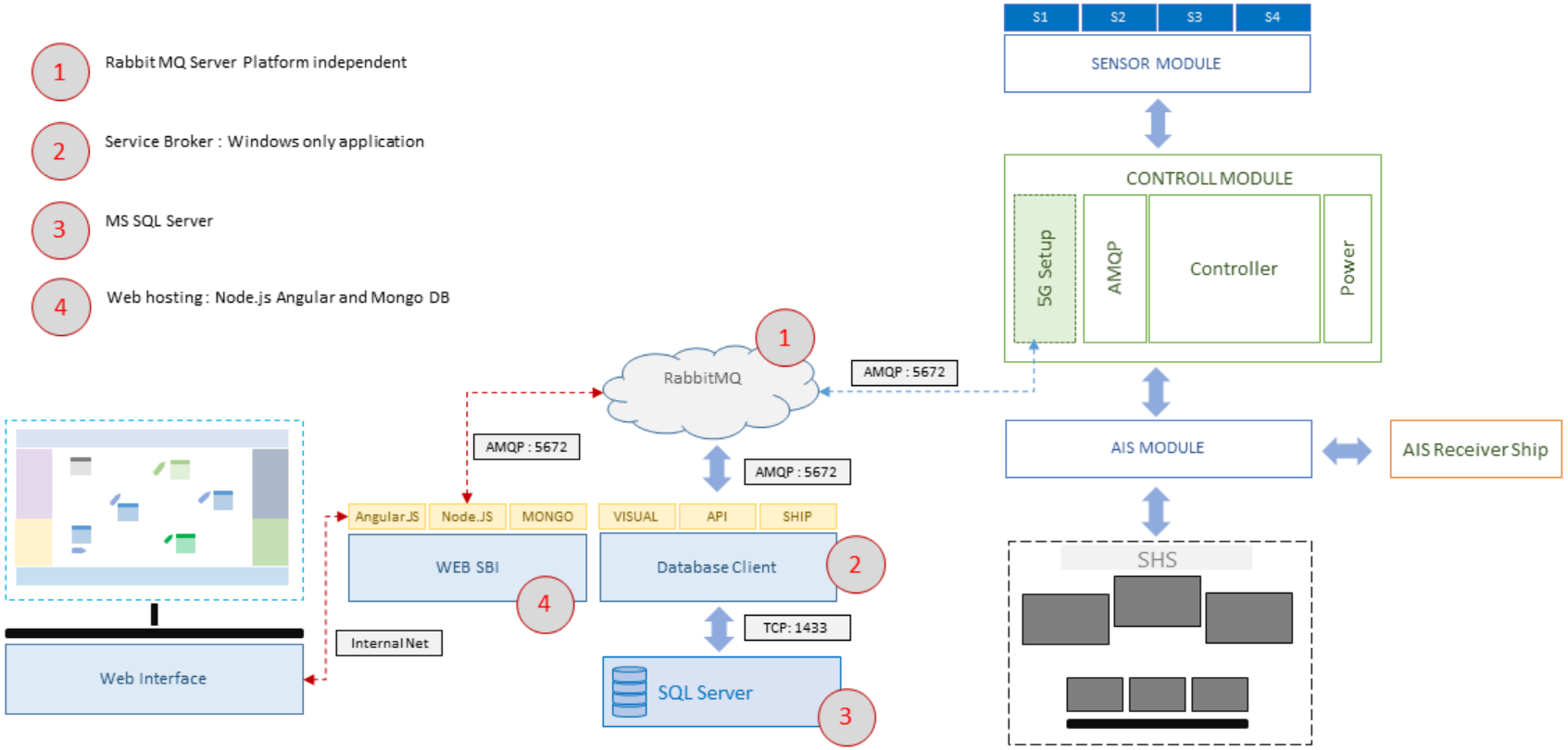
Infrastructure

Software Architecture



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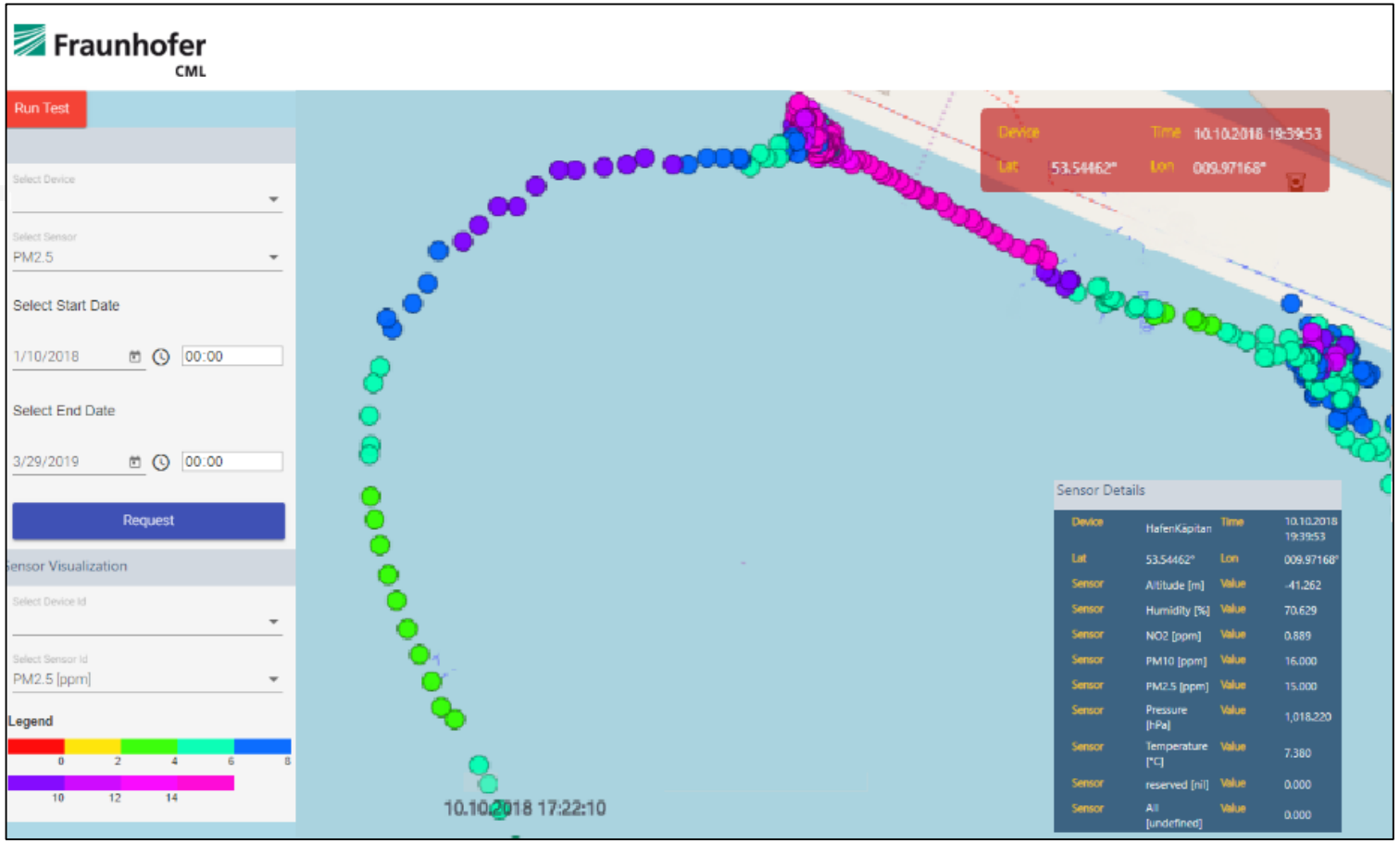
Technical Implementation

WebUI Components



Components

- MEAN-Stack (MongoDB, Express.js, AngularJS, Node.js) as framework
- OpenSeaMap
- AMQP Message protocol
- SQL Database

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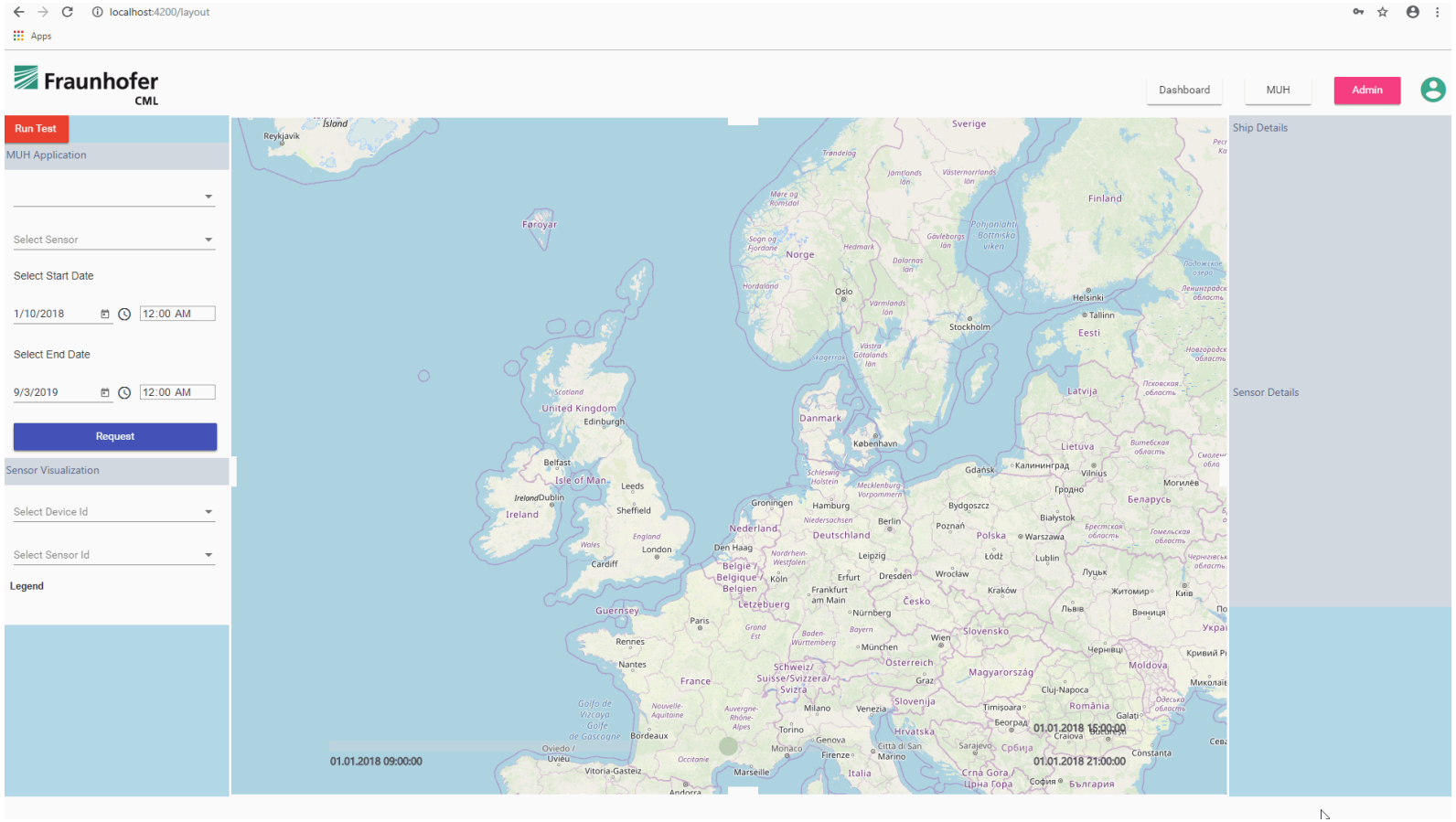
Results

WebUI Sensor Data Visualisation



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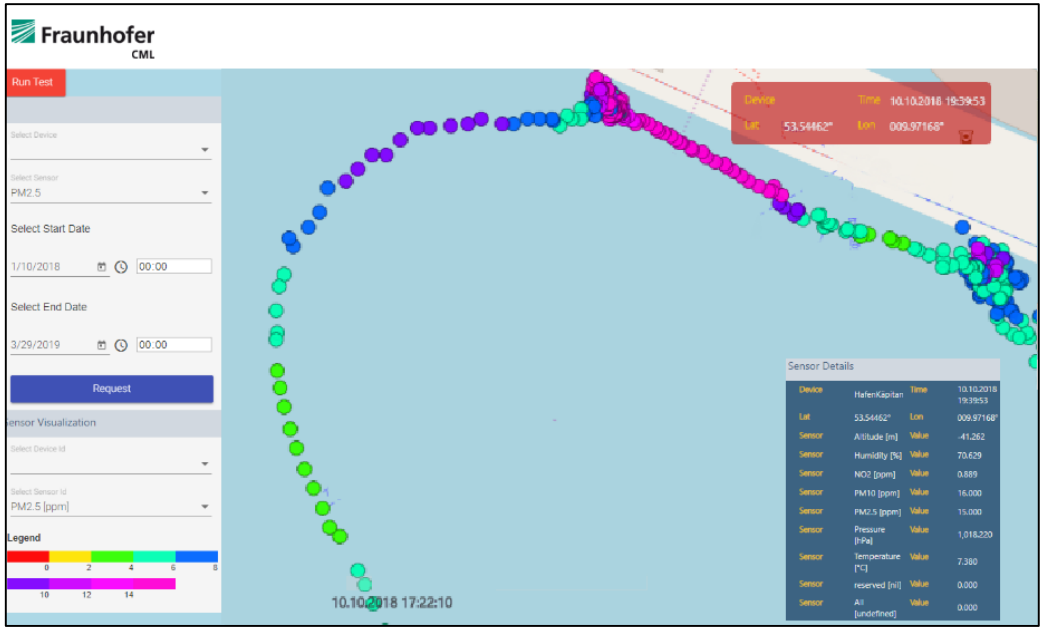
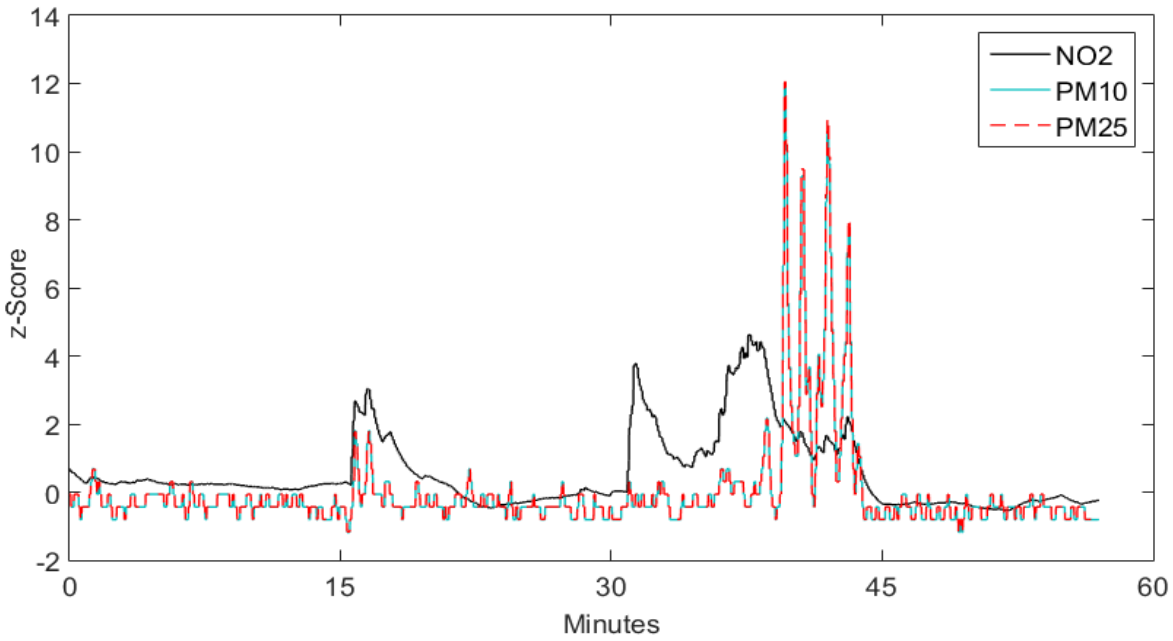
Results

Post-processing Sensor Data

- Stationed from minute 30 to 45 the ship was positioned behind a berthing passenger ferry





- User visualisation
- Dataset post-processing

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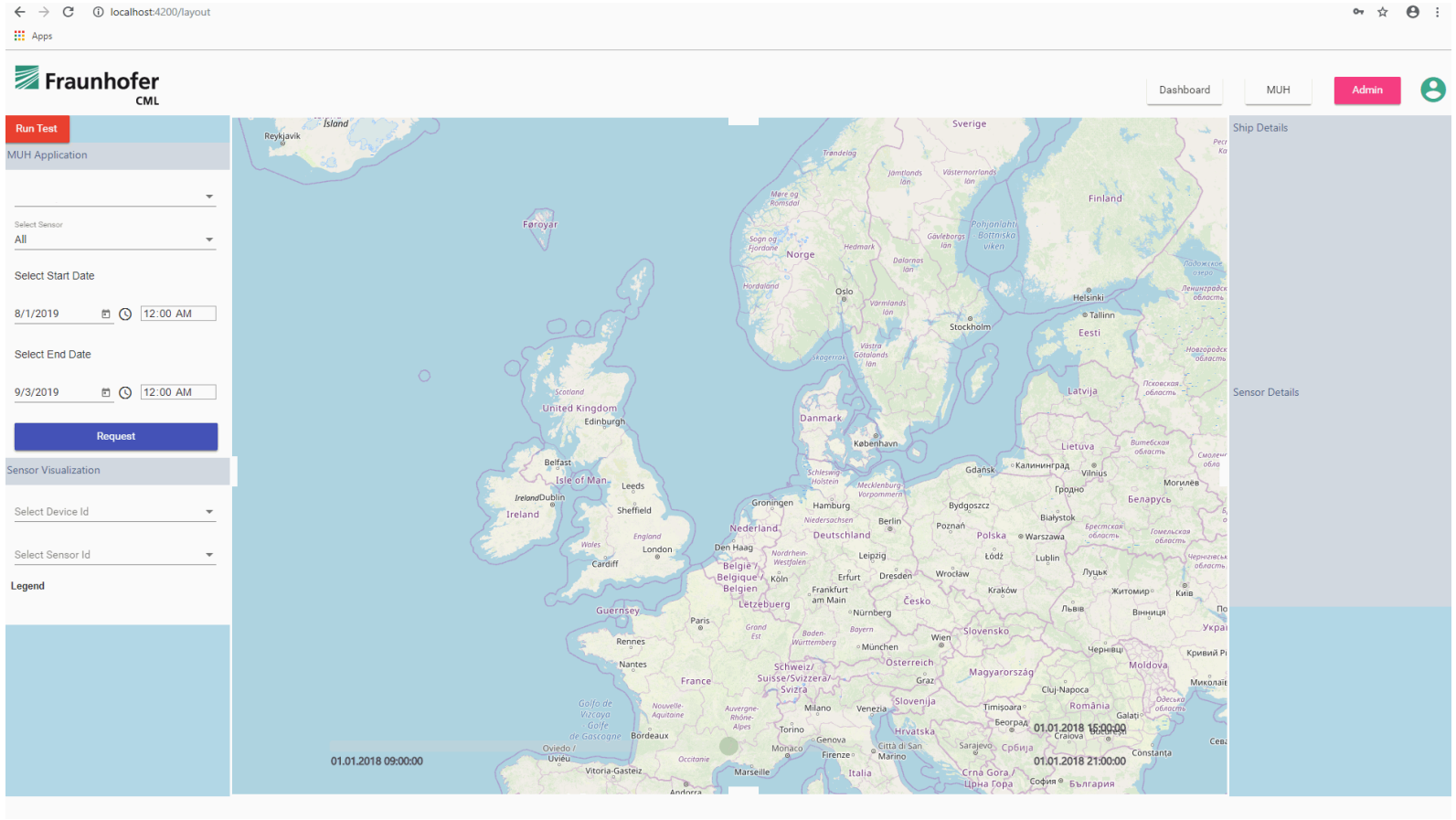
Results

WebUI: Visualising Sensor & Traffic-ship Data



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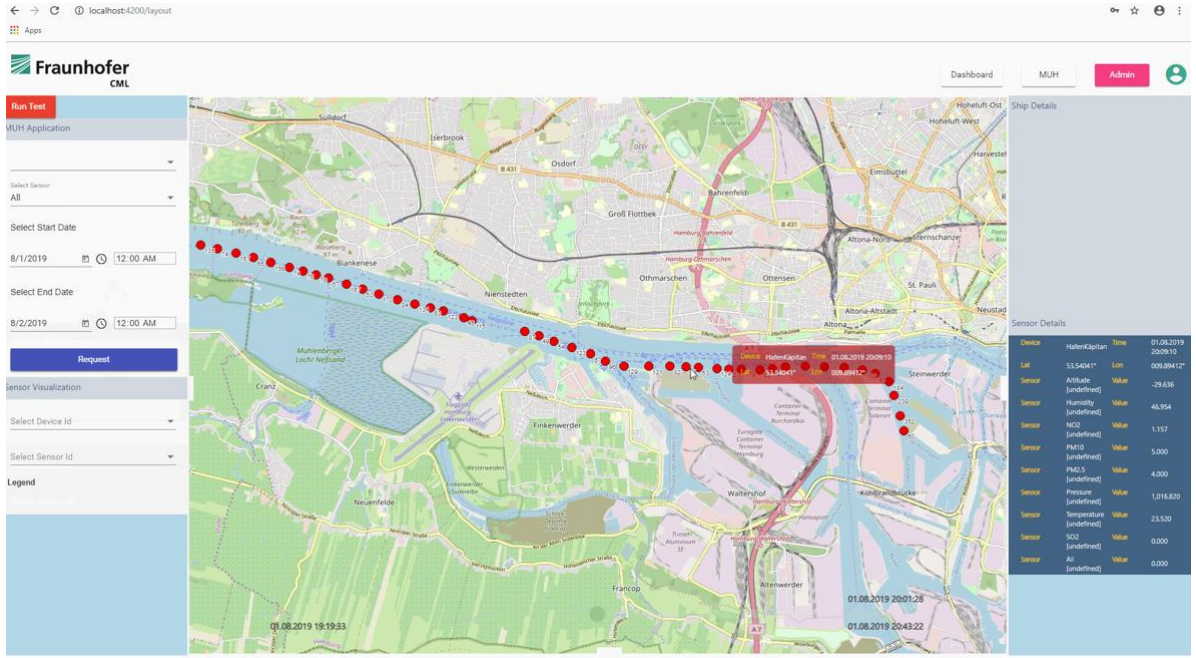
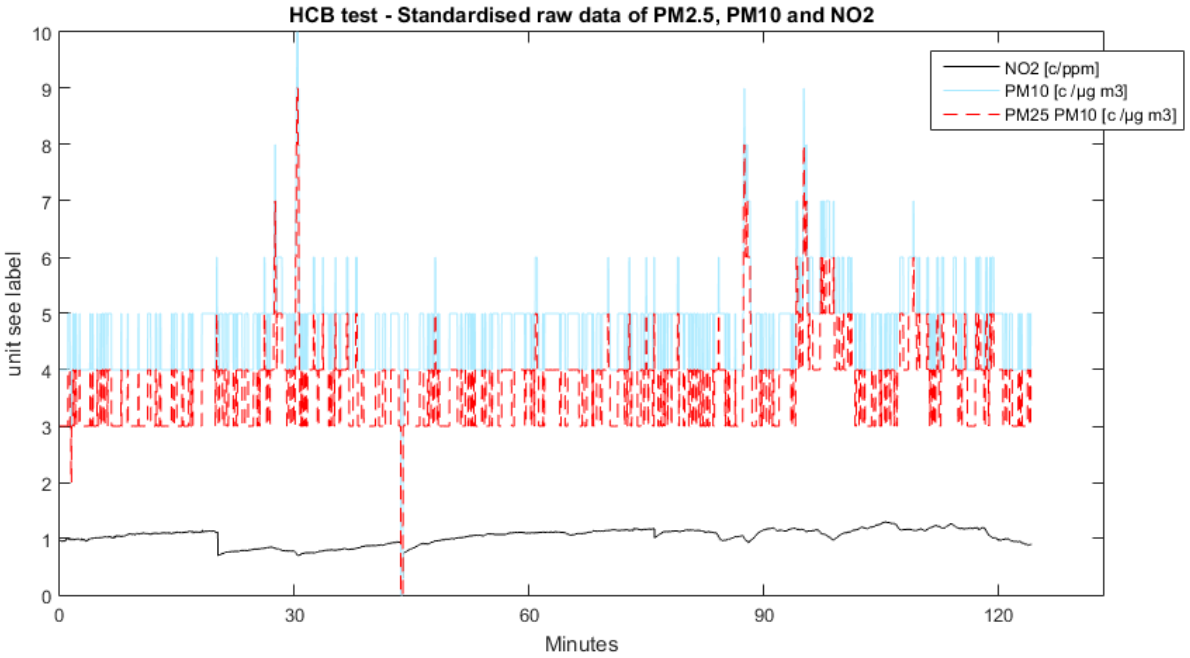
Results

Post-processing Sensor Data (2)

- Test run for along 40 minutes river Elbe in Hamburg port, capturing AIS messages
- Sampling rate 1 sec (2452 data points)

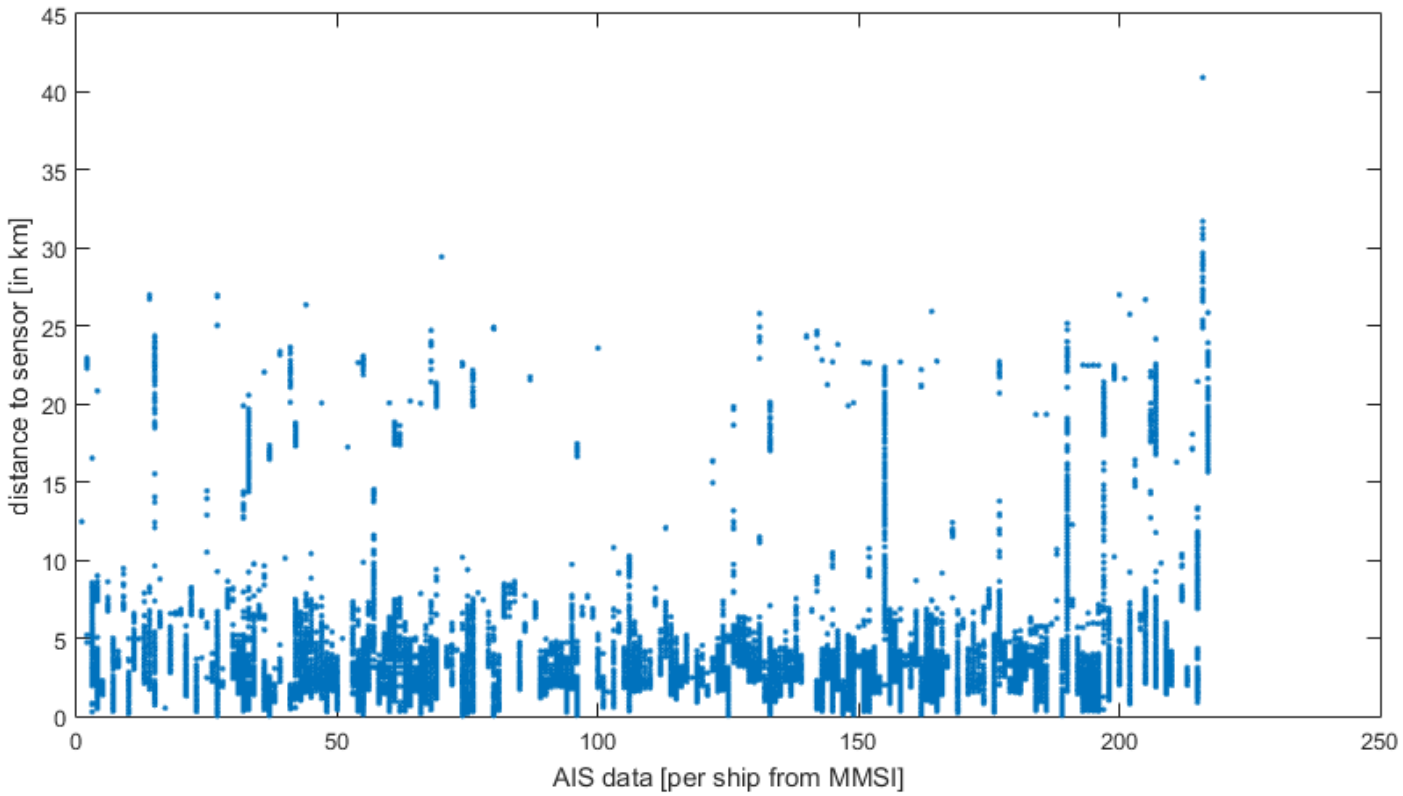




Results

Analyzing traffic ship data

- … while collecting AIS data at the same time
- … collected 13579 AIS messages, of which 1349 where within 1 km range of our ship/sensor box
- … which belonged to 179 different ships
- … of which 15 ships and 96 data points where within a distance of 200 m of our ship/sensor at the time of data collection



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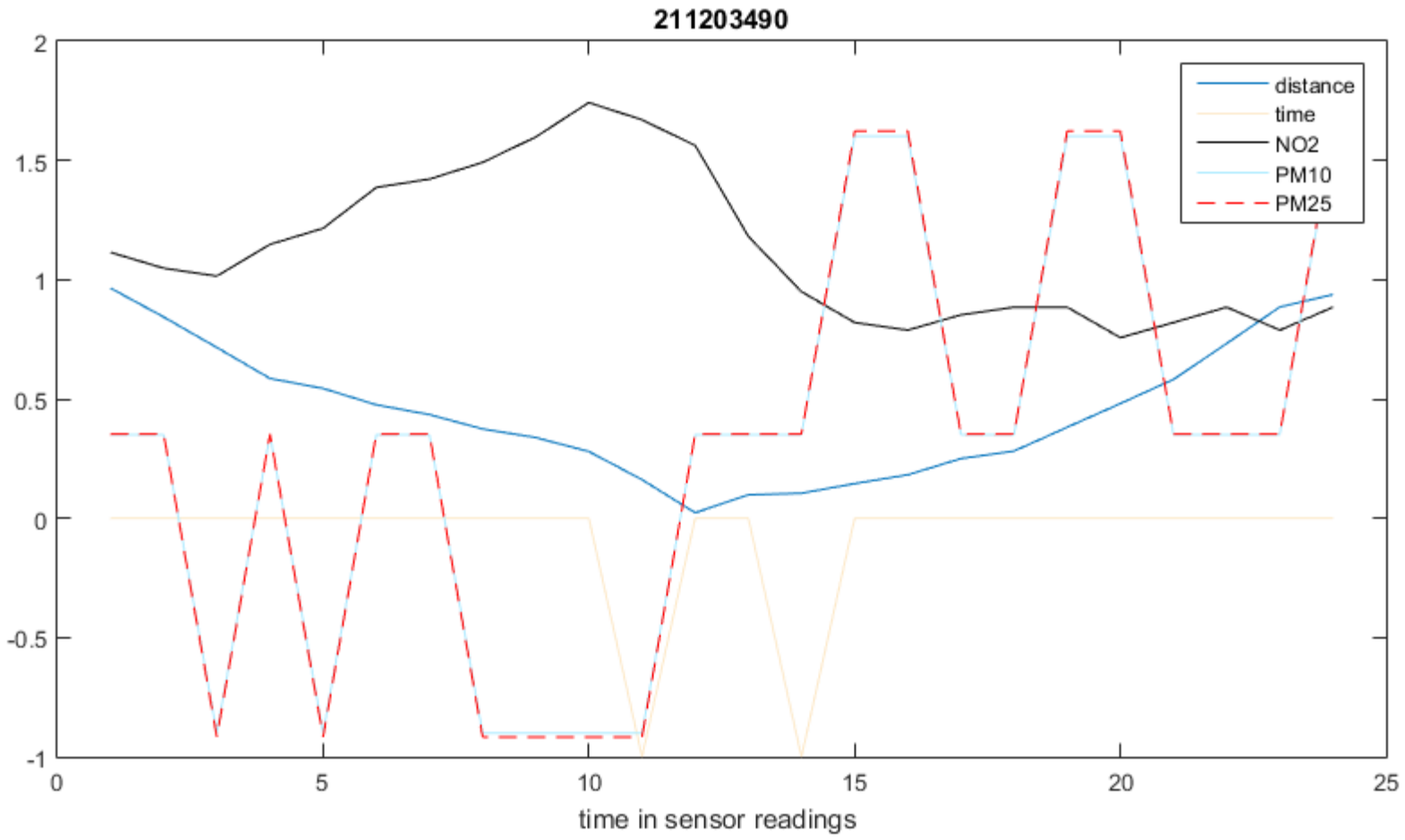
Results

Analyzing sensor & traffic ship data



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Results

Innovation & Limitations

Innovation

- Usage of low-powered SBCs (<10W) for interfacing sensors and ship bridge with shore centre
- Real-time data gathering over 5G network
- Modularisation for increasing scalability

Limitations

- Difficult to correlate dynamically acquired sensor data with past values of reference points
- Sensor values highly influenced by wind
- Device positioning on the ship may corrupt measurements

Disclaimer: Focus laid on application workflow, not on measurement accuracy (non calibrated sensors)

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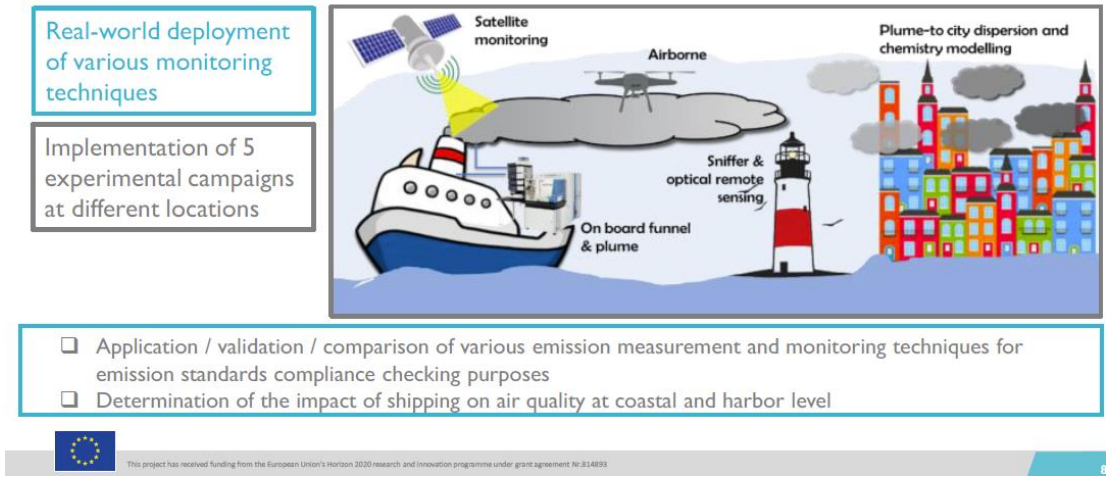
Future developments

SCIPPER (Shipping Contributions to Inland Pollution Push for the Enforcement of Regulations)

- ESU Hardware redesign
  - Upgrade for long term use in offshore environment
  - Calibrate low-cost sensors with high end systems over the long term (focus also on measurement accuracy)
  - Integration of wind speed and direction
- WebUI
  - Design and implement the Environmental Shipping Monitoring Centre (ESMC) for visualization and fusion of sensor data from multiple sensors and types
  - Area meshing with stationary bases for methodological detection of pockets of pollution

THE SCIPPER PROJECT



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