10.5281/zenodo.3989028

Project	GUTTA
Work Package number	3
Work Package title	Strategic potential for a greener and more integrated CB maritime mobility
Deliverable number	D 3.1.3
Deliverable title	Collection of raw data of vessel propulsion and performance
Deliverable Responsible Partner	UniZd
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Deliverable due date	2019-09-30
Deliverable latest review date	2019-10-28

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1. Executive Summary

This activity is meant to collect most of the input data and knowledge necessary for carrying out subsequent GUTTA's activities by UniZd. A database of vessel performance and CO2 emissions (e.g. using data from trial, daily and voyage reports stemming from several maritime routes) will be created, based on this input dataset.

2. Introduction

This report will discuss deliverable D 3.1.3 (Collection of raw data of vessel propulsion and performance), its execution and the results achieved.

Raw data collection regarding fuel consumption and CO2 emission on ferry routes between Italy and Croatia is the first step towards creating a feasible CO2 emission prediction model on the afore mentioned routes, therefore one of the most important contributions of UniZd to the GUTTA project.

3. Methodology

Several methods of data collection were used including:

- collecting the actual fuel consumption and emission data from Jadrolinija ferries on routes between Italy and Croatia
    - MV 'MARKO POLO' – MAY 2019
    - MV 'ZADAR' – SEPTEMBER 2019
    - MV 'DUBROVNIK' – OCTOBER 2019 (yet to be collected)
- Collecting the simulated fuel consumption and emission data using Wartsila ROPAX simulator
    - Still an ongoing process of data collection which will make up the bulk of the total data presented in the harmonized and queriable database due until the end of the second reporting period.

3.1 Data collection aboard Jadrolinija ferries

So far data from two ferries has been collected including passenger ships 'MARKO POLO', shown in figure 1, and 'ZADAR'. Data collection aboard the passenger ship 'DUBROVNIK' is planned for October 2019.

Figure 1 Emission measurement aboard passenger ferry MARKO POLO

Modifications to the ships propulsion plant, shown in figure 2, were needed in order to set up the device and test the compatibility of said device with the ships system. Upon successfully setting up the Testo 350 analyzer measurement and parameter collection process was initiated.

Figure 2 Modification on the flue gas line on passenger ferry ZADAR

Jadrolinija ferries are at sea during the night from 20:00 or 22:00 until 07:00 next day.

More specifically:

- MARKO POLO – 20:00 – 07:00
- ZADAR – 22:00 – 07:00

The measurements were therefore taken every day during the nightly sailing period.

UniZd team was on board 'MARKO POLO' from May 7th until May 16th, and on board 'ZADAR' from September 16th until September 18th.

Along with the emission measurements we also took all the necessary engine room and navigational parameters including the daily fuel consumption.

Upon finishing the measurement trial, we created a database of the accumulated data and are currently in the phase of analyzing mentioned data.

The method used is flue gas emission analysis using 'Combustion and emission analyzer Testo 350', shown in figure 3, as well as monitoring and recording all necessary ship parameters during the voyage.

Figure 3 TESTO 350 and the parameter data sheet

The recorded parameters are listed below.

- Testo 350 measurements:
  - Tstack - Flue gas temperature
  - O2 - Oxygen
  - CO2 - Carbon dioxide
  - CO - Carbon monoxide
  - NOx - Nitrogen oxide
  - SO2 - Sulphur dioxide

- Measured operational parameters:
  - Speed over ground
  - Vessel course
  - Draft
  - Sea water temperature
  - Air temperature
  - Main engine power
  - Auxiliary engine power
  - Fuel consumption
  - Fuel injection index

  - Exhaust gas temperature after the cylinder
  - Exhaust gas temperature after the turbine
  - Main engine RPM
  - Propeller shaft rpm
  - Auxiliary engine RPM
  - ME & AE cooling fresh water temperature
  - ME & AE lube oil pressure
  - Controllable pitch propeller angle
  - Stabilizer status
- Observed operational parameters:
  - Wind speed
  - Wind direction
  - Wave height
  - Wave direction

Figure 4 shows the emission measurement and parameter recording process, while figures 5 and 6 show the field measurement team aboard passenger ferries 'MARKO POLO' and 'ZADAR'.

Figure 4 Measuring the emissions and parameter recording aboard the passenger ferry ZADAR

Figure 5 UniZd field measurements team aboard the passenger ferry MARKO POLO

Figure 6 UniZd field measurements team aboard the passenger ferry ZADAR

3.2 Simulated parameters

The engine room simulator has been acquired using GUTTA project funds which will be visible in the financial report. The bridge simulator however has been acquired using funds from other projects. This is crucial because the engine room simulator, while a good source of data in its own right, is not enough for the needs of the project. Joint operation between the bridge and the engine room is needed in order to create the highest quality database on which the model will be formulated.

The bulk of the actual data was collected using the NTPro 5000 Navigation Simulator and Wartsila ROPAX engine simulator, shown in figure 7, which is still an ongoing process due to late installation and problems related to joint operation between bridge and engine room simulators.

- Length, overall – 125 m
- Breadth, molded – 23.4 m
- Designed draft, molded – 5.3 m
- Service speed – approx. 19 knots

Propulsion:

- 2 x MAN 8L32/40 Four stroke, medium speed, turbocharged, non-reversible main diesel engine, MCR 4,000 kW at 750 RPM
- 2 x Controllable Pitch Propeller (CPP)
- CPP Bow Thruster 1000 kW
- 2 x Fin Stabilizers

Electric Plant:

- 3 x Diesel Generator 600 kW, 450V AC, 60 Hz, 3 ph (diesel engine – CAT 3508B)
- 1 x Shaft Generator (PTO) 1160 kW, 450V AC, 60 Hz
- Emergency Diesel Generator 260 kW, 450V AC, 60 Hz

Figure 7 Wartsila ROPAX simulator specifications

With the joint operation mode on the simulators in fully operational mode we can collect a wider variety of the ships operational, fuel consumption and emission data in different environmental situations (different wind, wave and sea states) with the ships autopilot holding the designated course. This enables us to accumulate a higher quantity of individual simulations, more relevant parameters and a more comprehensive database than using only engine room simulator.

The parameters acquired with the simulator are listed below.

List of simulated parameters:

- Main engine shaft power
- Aux engine power
- Propeller pitch
- Propeller RPM
- Fuel consumption
- Main engine fuel rack
- Fuel oil flow
- Fuel service tank level
- CO2 emission
- CO emission
- NOx emission
- Vessel speed
- Wind speed
- Wind direction
- Wave height
- Wave direction
- Hull fouling

4. Results

The initial results of data collection have indicated a clear effect different weather and load patterns have on fuel consumption and CO2 emission.

5. Conclusions

Since the collected data is still being studied and analyzed, more comprehensive and detailed results will be reported in the future. However, it is clear that already completed and further data collection and analysis could provide interesting insights in fuel consumption and CO2 emissions on ferry lines between Italy and Croatia and will be a great tool to base the future model upon.