
# ACOUSTIC CAMERA SHIP NOISE MEASUREMENTS DURING DOCKING OPERATIONS: A CASE STUDY IN GENOA

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Port noise is characterized by the overlapping of multiple sources, of which ships represent one of the most relevant. The study of the noise emission from ships is a difficult task due to the dimensions of the ships and the simultaneous emission from different onboard sources. The noise coming from the port causes discomfort and complaints, particularly in ports which are surrounded by hills with residential buildings, such as the port of Genoa. This work aims to characterize the emission of a ship during docking in the port of Genoa using an acoustic camera. Acoustical images and videos of the arrival and of the docking manoeuvres of Ro-Pax vessels were obtained from different positions using an acoustic camera suitable for outdoor long-range measurements. Acoustical maps obtained from the measurements are used to characterize the spatial distribution of the noise and to detect the location and level of the main sources. Results from the overall sound pressure levels were compared with standard sound level meter measurements. In this way, some sources were precisely located in the ships, mainly on the ventilation system and engine exhaust. This approach confirms that acoustic camera measurements are useful for obtaining relevant empirical information that can be used to model the port noise and to propose possible mitigation strategies, overcoming the limitations of traditional techniques based on sound level meters measurements.

Keywords: acoustic camera, beamforming techniques, port noise, ship noise, noise measurements.

## 1. Introduction

Ports in Mediterranean countries are usually near to urban areas, and the intense activity developed in these places generates high noise levels that affect the health and comfort of the population. The problem of noise evaluation and control in urban areas coming from the port area was subject of several previous studies, e.g. [1-3]. Different acoustic measurement techniques can be used to evaluate and identify the sources and develop effective control strategies; a comparison of the techniques suitable for

airborne noise emission can be found in [4,5]. Common techniques and ISO standards used to characterize industrial noise do not apply to the measurement of noise coming from large vessels mainly because of the long distances from the sources and the complexity of the vessels themselves [6]. A novel approach using the acoustic camera in this context was presented in a previous work [7] and some examples, such as the loading-unloading operations, were discussed. In the present work, an acoustic camera is used to analyse noise in port during the arrival and docking phases of a ship. This approach is not yet very common, and the use of an acoustic camera in a port noise context is rarely seen in literature; some examples can be found in [8-10]. The acoustic cameras are powerful tools that combine images obtained with a camera with acoustic maps obtained from analysing multiple audio signals acquired by a microphone array. The source localization can then be obtained by applying different beamforming algorithms to the set of recorded audio signals [11].

This paper presents a case study that involved the use of an acoustic camera to measure ship's noise during docking operations at Genoa port.

## 2. Method

Figure 1 shows the selected locations where the measurements in the Genoa port (Porto Antico area) were performed. As it can be seen, this zone is characterized by a C shape and is located in a densely populated area. The decrease in the port activity during the Covid-19 pandemic was profited to realize measurements of routine manoeuvres, reducing the possible overlapping by secondary sources commonly present in this port (one of the most important ports in the Mediterranean Sea). Two ships (ferries) were measured during docking and loading-unloading operations.

The main phases can be resumed as follows:

- background noise at location 1. Only port activity. During the measurements, there were no moving ships;
- pass-by of ferry 1. It was measured from location 1 at the entrance of the port zone;
- docking maneuver of ferry 1. Measured from location 1. The ship used auxiliary motors to turn and approaching the docking zone;
- Unloading phase (ferry 2) measured from location 2.


Figure 1: Satellite map indicating the measurement locations and the trajectory of the ferry.

The measurement setup consisted of an acoustic camera (gfai tech GmbH Star48 AC Pro microphone array), a 48-channel data acquisition system mcdRec, and a laptop. This particular microphone array is designed for environmental noise and long-distance measurements. The measurements were compared with ones taken by a class 1 sound level meter (Larson Davis Model 824).

## 3. Results

Figure 2 shows the background noise spectrum and the noise spectrum during the pass-by of ferry 1. The acoustic camera sound pressure level differed from the sound level meter one by 1.6 dB(A) during background measurements and 0.6 dB(A) during pass-by. The sound energy increment is evident in all the third-octave bands but mainly in the low and high-frequency zones, even if the signals were A-weighted.

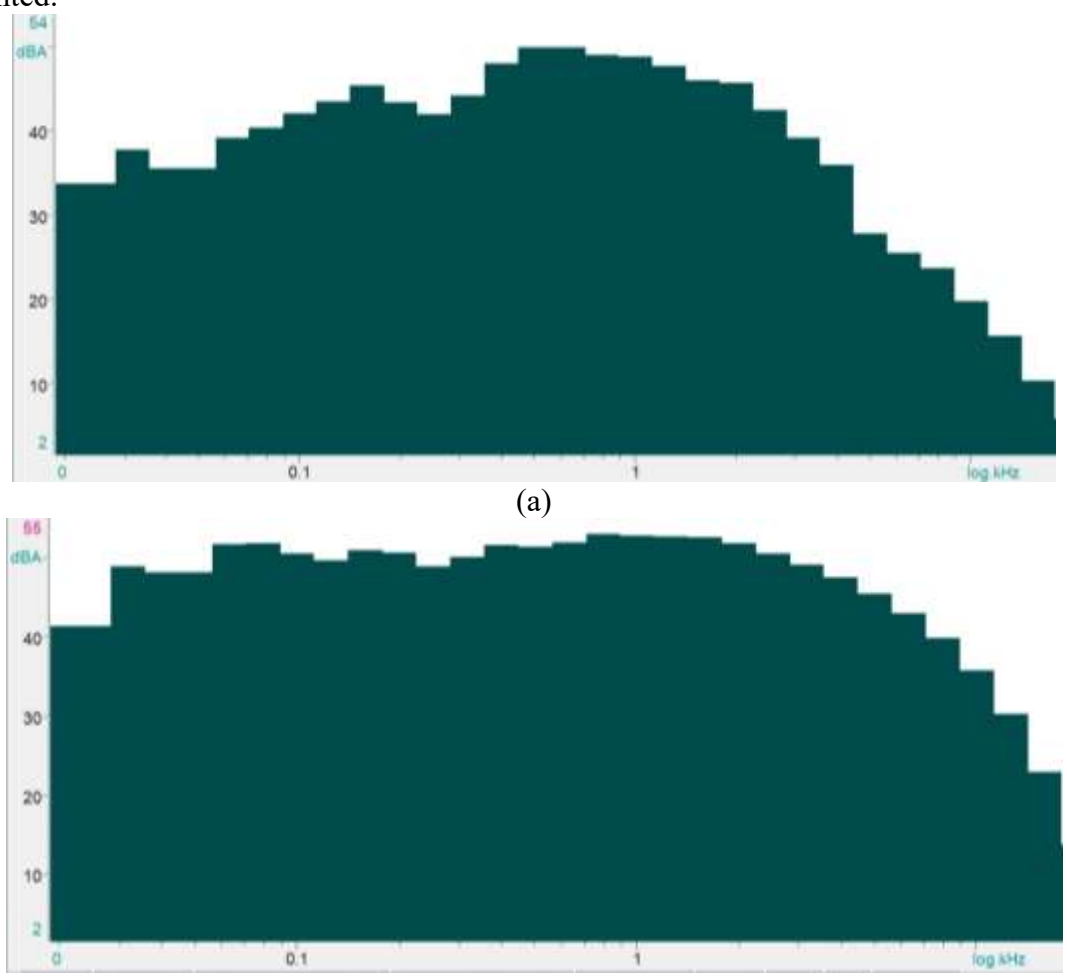


Figure 2: Noise spectrum: (a) background noise, (b) pass-by of ferry 1.

The acoustic camera proved to be useful to identify the location of the main sources in the front and in the rear part of the ship (near the main propellers). Figure 3 shows the main sources during the pass-by of ferry 1. Secondary sources were detected in ventilation ducts. Even with a drastic reduction in port activity during the pandemic, a second ship was recorded while passing by, evidencing the intrinsic complexity of the soundscape in a harbour.

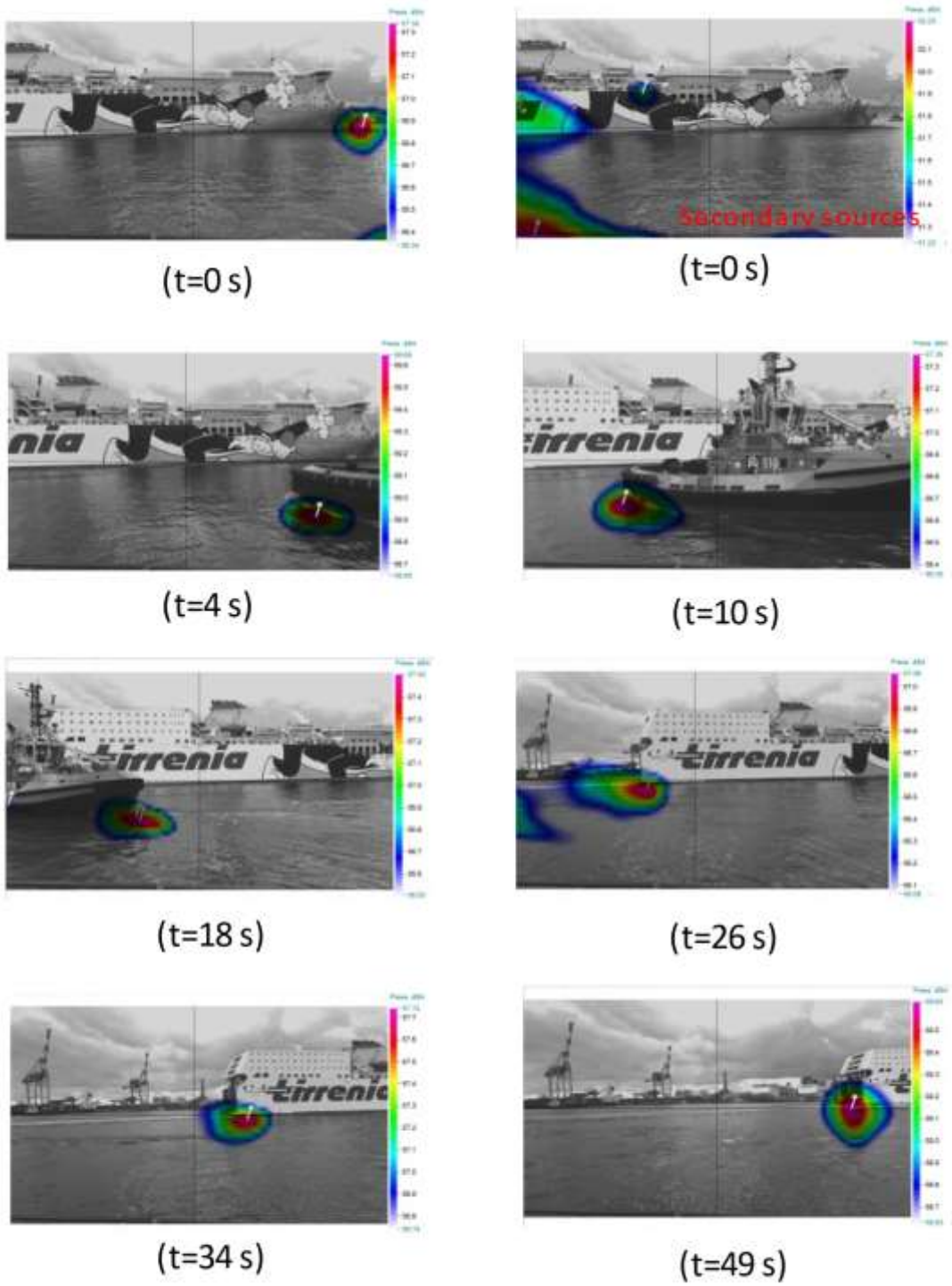


Figure 3: Acoustic images during ship pass-by at low speed. A small ship passes in the opposite direction from seconds 3 to 20. The perceived noise level increased from $L_p$=56.5 dB(A) (background noise) to $L_p$=63.4 dB(A). The estimated source power level was $L_w$=105.9 dB(A).

Figure 4 shows the docking operations of ferry 1; it is interesting to note that the acoustic images show the location of the main sources near the thrusters (on the starboard side of the ship) used to make the ship turn and approach the quay. After the docking (t=87 s), the perceived noise level decreased by almost 10 dB(A), and some other sources in the port area became relevant.

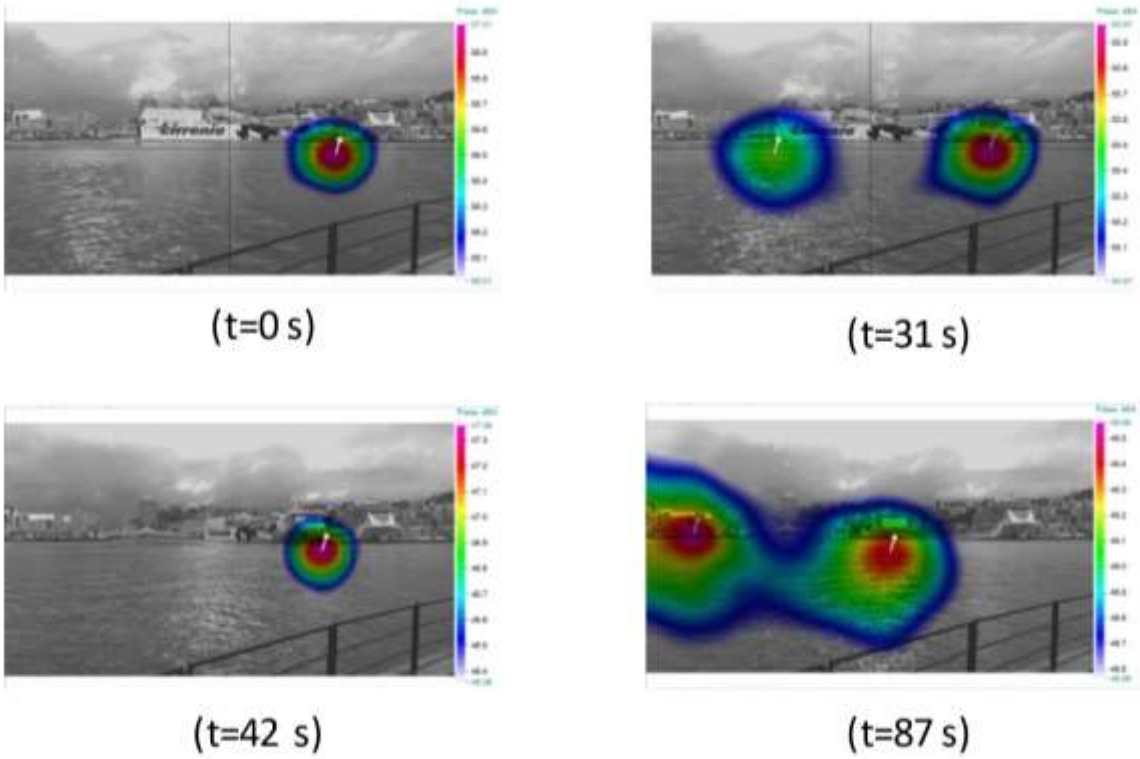


Figure 4: Acoustic images during docking.

Figure 5 shows the intense activity during the loading and unloading activity of the ferry 2. Multiple moving sources are present, mainly trucks used to move the ship's load. It is also notable the presence of a relevant source near the main exhaust system (funnels) of the ship, even if the ship is at quay. This measurement is coherent with the previous results reported in the literature.


Figure 5: Acoustic images during loading-unloading of ferry 2. Noise sources are located in the funnel, the open stern ramps, and the trucks transporting the ship's load.

## 4. Conclusions

Ship noise measurements during docking operations using an acoustic camera were presented in this work. This study was performed in the Genoa port, where docking and discharge operations were studied using acoustic images, noise spectrums, and overall values of the sound pressure level. The acoustic camera proved to be able to measure large vessels during docking and mooring manoeuvres, overcoming the problems related to long-distance measurements and sources complexity.

The sound pressure levels measured with the acoustic camera were compared with sound level meter measurements, showing good agreement. The sound sources were located near the main propeller, the auxiliary motors, and the exhaust systems. During the loading and unloading of the ferry, multiple moving sources (trucks) were also found to be relevant to the overall soundscape of the area.

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