Norsonic Acoustic Camera

Identifying low-frequency tonal noise in windy and noisy conditions

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Measurements on LNG gas terminal in Stavanger, Norway, September 2014

*These recordings were made with the Nor848A-10 1.0 m acoustic camera with 256 microphones ,
now replaced by the Nor848B acoustic camera system.*

Problem

A large LNG gas facility (approximately 300m x 150m) producing 300 000 tons of LNG annually is situated in a terminal area with the nearest populated area at a distance of around 1 km. Within the gas production facility, a low-frequency tonal noise at around 500 Hz is generated causing complaints from nearby neighbours. The tone imposes a more stringent noise requirement on the facility, forcing noise reducing actions being made on the source.

In addition to the tonal noise, the entire LNG gas facility is rich in noise emitting sources, including lossing and loading of maritime vessels, which further complicates the source location of the single tonal noise source. Also the location of the facility at the coastal regions of the western part of Norway, ensures that windy conditions are frequent, with wind noise further impeding the quality of acoustic recordings.

Based on measurements with hand held sound level meters, the problem area was narrowed down to be a large pipe in the midst of the facility. However it could not be determined if the emitted tonal noise was from the entire pipe itself, or if it originated at a specific part of the pipe. There was also uncertainty whether there existed multiple sources within the pipe, for instance at both the base and top layer. In the worst case the noise insulation would have to be performed over the entire pipe length, which could have been a very expensive solution.

Measurements

The measurements were conducted over two subsequent days with the Nor848A-10 1.0m and 256 element acoustic camera. The camera was plugged into an external battery pack for easy transportation and mobility. The entire measurement system could easily be moved around to different positions to get a noise mapping of different sides of the pipe. Different positions would also ensure that noise sources being different from the source of interest

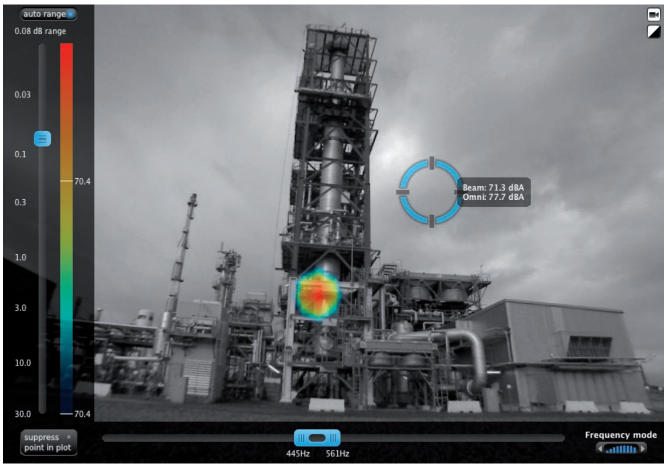
would not inflict too much on the measurements. The primary measurements were conducted at a distrance of approixmately 25-30 meters from the pipe. In addition measurements were made close to the source from 2-5 m distance by climbing up onto the pipe with the camera. Since the flight of stairs were too narrow to get the 1.0 m camera through the stair's safety rails, this was solved by hoisting the camera up and down by rope.

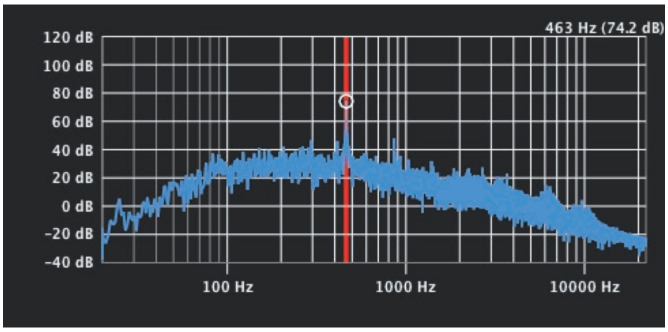
Results

By positioning the center of the array towards the pipe and adjusting the frequency to display only coloring within the 500 Hz 1/3-band, the noise source was located within seconds, and the source producing the tonal part from the pipe was detected. Measurements from different measurement positions also confirmed the source location.

By placing the virtual microphone on the localised source and using the spectrogram function, it was easy to verify the position of the source emitting a tone at 460 Hz.

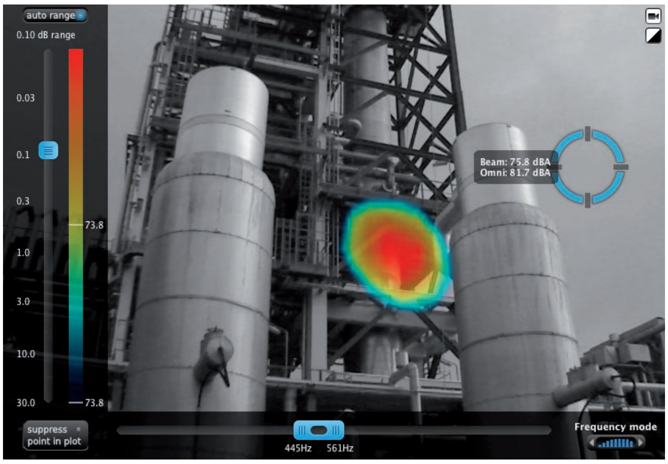
Although the measurement location had quite windy conditions, the wind noise did not affect the measurement results at all. Wind noise can be viewed as spatially white, which means that wind noise sampled at different places in space, as is done with the Nor848A, is not correlated from position to position. When many different signals from many

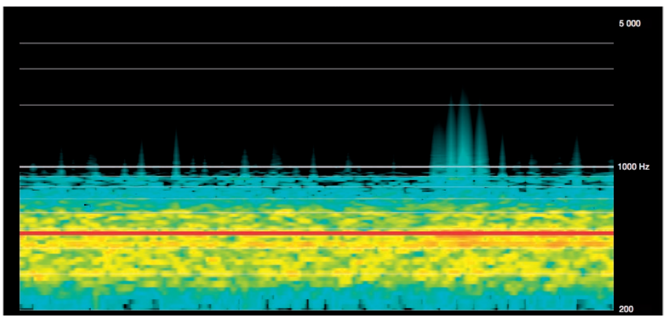


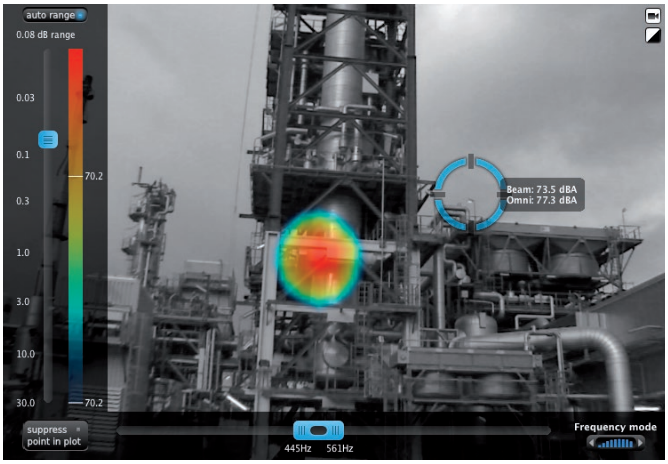


microphones are added in the beamforming algorithm, the wind noise will be added out of phase and attenuated proportional with the number of microphones being used.

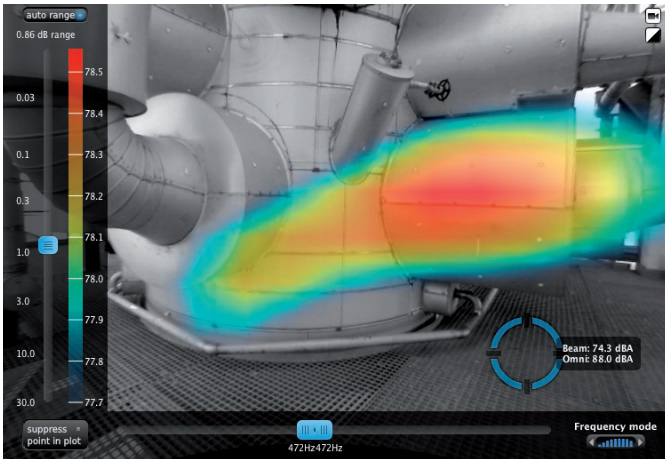
With the acoustic camera it was possible to detect the tonal sound of the most crucial parts of the turbine. This meant that the facility could focus on and implement noise reduction actions in the right places.



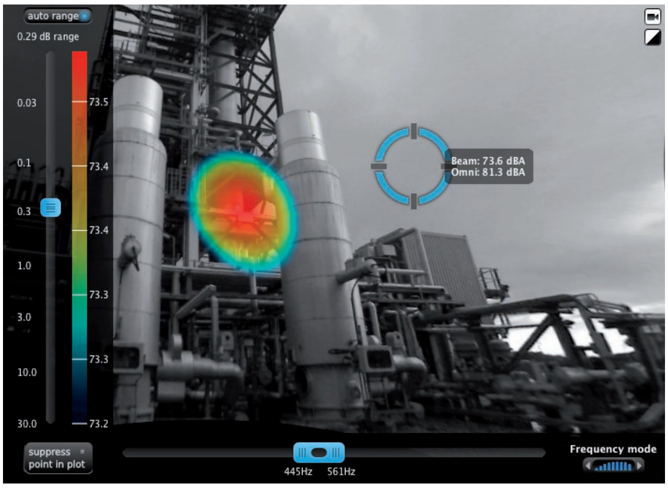




After pin ponting the location of the noise source, further analysis could be made with measurements performed closer to the source of interest in order to further determine the position and cause of the generated tonal noise.



Another useful function is the so called acoustic eraser, which is a functionality that enables source suppression in order to find interesting plotting points. Seen on the images from the acoustic camera software on the next page is a recording of the pipe without and with point suppression enabled. Seen in the bottom image, the acoustic eraser is seen as a red circle with a white x and placed on the tonal source in the image to suppress it. By enabling the acoustic eraser, and dragging the point suppressor to the desired location, one could further identify if the pipe had other locations that generated tonal noise. As seen in the bottom image, no such additional tonal sources were found.



Nor848B Acoustic camera

The Norsonic acoustic camera is a module based approach to acoustic camera that gives the user both portability and great resolution for a wide range of measurement situations. The array dish is based on a hexagon shape, given it both its name, and the ability to combine several tiles into larger systems.

Acoustic beamforming arrays, commonly known as acoustic cameras, enable the user to visualise different sound sources at different frequencies and source strengths. The resolution and ability to resolve sound sources spaced closely apart, and at lower frequencies, is mainly decided by overall size and number of microphones of the equipment being used. Although image manipulation and deconvolution techniques on the beamformed results might give added resolution, in practise the properties of the array still influence the results. This size versus resolution criteria is the crux of the acoustic camera market. Users want something that is small, light weight, and portable, while at the same time having excellent resolution, and the ability to go low in frequency. This has been an impossible demand for a single system – until now.

Hextile - lightweight and portable

With a single Hextile, the user has a small, portable and lightweight acoustic camera that can be used for a wide range of measurement situations. The Hextile is a USB based acoustic camera, with a single USB cable for both power and data transfer – no extra battery cable needed. The array is made from robust and lightweight aluminium, has 128 MEMS microphones, and is less than 3 kg in weight while having a maximum diameter of 46 cm. The low frequency limit for the Hextile is 410 Hz.

Multitile - great solution

For users that require better resolution both in lower frequencies and overall, three single Hextiles can be combined to a larger Multitile system, consisting of 384 microphones with a maximum diameter of 96 cm. The low frequency limit for the Multitile is 220 Hz.

Multitile (LF mode) - low frequency measurements

For special low frequency applications below 1 kHz, it is also possible to utilise the Multitile in the low frequency configuration as the Multitile (LF mode). By placing the individual Hextiles further away, the maximum diameter of the complete array system is increased to 1.46 m, making it ideal for low frequency measurements. The Multitile (LF mode) is for low frequency measurements below 1 kHz, with a lowest frequency limit of 120 Hz.

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