Feasibility of noise monitoring in the cruise port of Warnemünde

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1 Situation

The Cruise Terminal Warnemünde is located in close vicinity to ancient residential areas. With respect to regulation of noise emissions from the terminal this spatially compressed arrangement poses a challenge on compliance with regulations for noise immission.

In the past 5 years, Cruise business in Warnemünde experienced an increase in passenger numbers while the number of berthing ships remained unchanged. The reason for this is most likely that even bigger cruise ships are being built. In general, the cruise business has been steadily growing for the last 15 year.

For terminal operation it is desirable that noise immission in the residential areas can be estimated on the basis of measured values at the terminal. The installation of a monitoring system on the terminal is deemed much easier. However, it must be ensured that appropriate locations on the terminal are chosen to ensure proper operation and reliability of the predicted values.

A measurement campaign was conducted to investigate feasibility and expected accuracy for multiple positions of a noise monitoring system at the terminal.

2 Background and objective

2.1 Requirements on noise immission

The cruise terminal is located in close vicinity to the old town of Warnemünde where most houses are purely used for living. For this reason, the area is rated as "residential area (WA)" with respect to protection against pollution. According to regulatory provision, this requires that rating levels of 55 dB during daytime and 40 dB during night time must not be exceeded. These rating levels are composed of all commercial and industrial business in the area. There is significant noise contribution from industrial activity of other companies such as a large shipyard. Therefore, additional immission from other contributors must be well below the limit value to endure that this is not exceeded in the presence of prior values.

The rating levels to evaluate immission at the receiver location are composed of average noise levels and additional components to take into account the disturbing character of certain sounds. An integral evaluation of noise sources in the area requires each source to be evaluated for

- A-weighted average level *LAeq*
- Duration with respect to
    - Daytime: Full period between 06:00 and 22:00
    - Night time: Loudest hour
- Additional disturbance by
    - Impulsive noise
    - Tonal noise
    - Low frequency noise (inside a room with protection need)
    - Information content, e.g. announcements

2.2 Scope of this study

This study discusses to what extent a monitoring system on the terminal may be applied for prediction of rating levels in the residential area. The monitoring system should be applied for feedback to terminal operators. Mitigation measures shall be applied in case of critical contribution of ship noise or noise from terminal operation. A noise measurement campaign was conducted to collect data for three purposes:

1. Feasibility of a **noise monitoring system**
    a. Identification of suitable positions and suitable concept
    b. Determination of accuracy
2. Check whether **immission requirements** are achieved for the residential area, evaluate contribution from berthing cruise ships
3. Acquisition of **emissions levels** of berthing cruise ships

2.3 Technical background

A typical cause for complaints about ship noise is low frequency noise from engine exhaust. The majority of ships produces electric power with diesel generator sets. The required power for cruise ships at berth accounts for several megawatts which is typically produced by large medium speed engines. These engines radiate strong tones in the frequency range below 100 Hz. If not designed very thoroughly, the exhaust pipes of these engines – located at great height of 40 m and more above quay – radiate high sound power into the environment. The attenuation of building facades is typically very low in this frequency range while they attenuate higher frequencies rather well. The result is an audible impression of low frequencies only inside the building. It was shown in several studies that this can induce physical feeling of discomfort, interruption of sleep and other severe reduction of living quality. Due to the strong influence of building details on the low frequency level inside a building, this value cannot reliably be predicted by a noise monitoring system without knowledge of the buildings' structure in the surrounding area.

Additionally to the engine exhaust, a cruise ship is equipped with several other noise sources which are distributed all over the ship. Typical examples are ventilation openings for air conditioning and technical spaces. For noise measurements in vicinity of the terminal this poses the challenge that most locations of ventilation openings are not known to external measurement on shore. Therefore, at close positions it can happen that a ventilation opening is located in a very close distance (e.g. 20 m) to the microphone even though all noise is assumed to originate from the exhaust pipes in much larger distance. For the measured noise from the ventilation opening, a significant error in calculated source level can be expected due to erroneous distance.

Nevertheless, close positions are included in this study to quantify tolerances of a noise monitoring system on the terminal building's roof. This position would provide more safety than other positions in vicinity of the road. Hence, it would be preferred if achieved accuracy is found sufficient.

3 Investigation method

This project was based on noise measurement data which was collected in Warnemünde during the weekends 14th to 16th September and 22nd to 23rd September. The dataset was collected at the terminal as well as close to one relevant receiver location in the residential area. The data was evaluated for the three purposes as mentioned in the scope.

Three acoustic data sets were recorded (see Figure 6):

1. One continuous measurement station in the residential area *Am Strom 4*
2. One continuous measurement location at the terminal
3. Mobile measurements at up to 10 locations

3.1 Feasibility of a noise monitoring system

The noise monitoring system shall be installed on the area of the terminal. For practical reasons, this location yields many advantages compared to installation at the relevant receiver point: The terminal is better protected against intrusion from non-authorized persons and it requires significantly less time for administrative procedures to approve by authorities. However, measurement at the terminal requires a method to translate results into a prediction of noise immission in the residential area. In this project, one translation method was proposed and evaluated for achieved accuracy.

3.1.1 Separation of noise contribution by statistical evaluation

There are multiple noise sources present at the terminal site as well as in the residential area. As shown in Figure 1**Fehler! Verweisquelle konnte nicht gefunden werden.**, these are audible over varying distances, mainly dependent on their source level and height. At every observer position, there are typically sounds detected of local sources like talking people or running car engines as well as of sources with larger audible range like a cruise ship. The local sources are audible only in their close vicinity. For example, the running engine of a car can be well hearable at the terminal while it is not detectable in the residential area. At the same time, the cruise ship could be audible in both locations.

With respect to a noise monitoring system this observation requires a method to distinguish local sources with small audible range from those sounds with large audible range. The prediction of receives noise levels can only be made for sounds which are detected in both locations. For the special case of the cruise terminal Warnemünde we assume that a continuous noise floor is generated by the cruise ships at berth which operate in a condition with very little fluctuations. The radiated noise level of the continuous noise sources like engine exhaust and ventilation fans is nearly constant over time while most local noise sources on shore change level over time. In the examined location there is only minor contribution present from other continuous noise sources like big roads. For this reason, we assume that the noise floor represents sounds from the cruise ship. It is characterized by the level *L95* which is exceeded in 95 % of a chosen period of time. In this case, 15 minutes time windows are chosen to describe the continuous ship noise by means of statistical evaluation. In ports, where the cruise ship does not dominate the noise immissions or where other stationary noise sources such as highways or industrial sites contribute noise over long periods, the described approach is not suitable. Uncertainties also appear due to the increase of the overall city noise floor according to the time of day or to single local continuous noise sources such as supply trucks with running cooling aggregates.

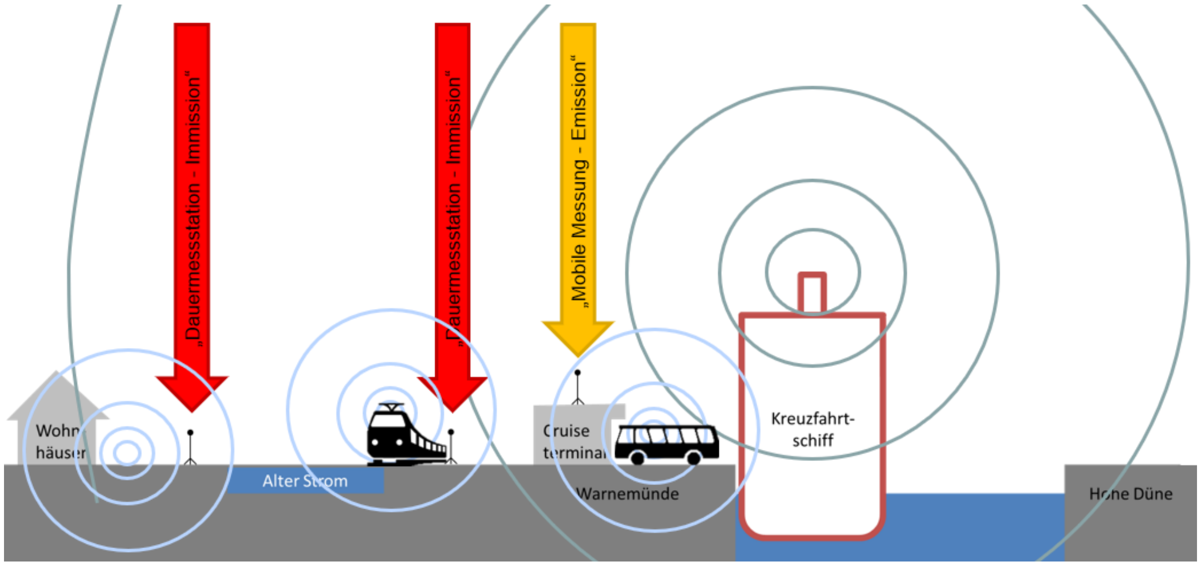


Figure 1: Schematic sketch of typical noise sources in vicinity of the terminal and residential areas.

3.1.2 Evaluation of measurement quality by SNR

According to relevant standards (e.g. ISO 1996[1]), the quality of a noise measurement must be assessed on the basis of a signal to noise ratio (SNR). One method to derive this quantity is comparison of measurements “with source switched on” to “source switched off”. There is no need for correction if the result of the measurement “with source” is at least 10 dB higher than the value “without source”. For the cruise ship at berth, this comparison is barely possible for two reasons:

1. In most cases, the ship arrives in the morning hours between 05:30 and 08:00 when the activity of other noise contributors like road traffic and industrial noise changes significantly. Since the berthing requires at least 30 minutes, a baseline measurement would be made with at least one hour time before measurement of ship noise. In this period of time, the acoustic scenery can be completely different. And in this case, the background noise measurement would be worthless.
2. The cruise ship at berth cannot be switched on and off for safety reasons. Even when connected with available shore power, there are always vital systems running like ventilation or boiler.

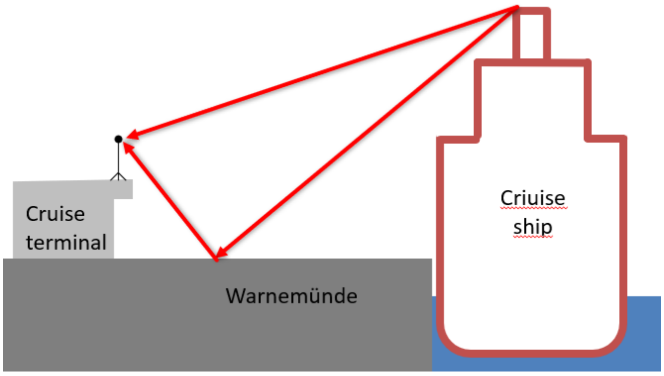
In this project, two individual methods were applied to assess validity of the assumption the *L95* represents ship noise:

1. For broadband levels of continuous measurement locations: The *L95* of A-weighted broadband noise level *LAeq* over time was evaluated in 5-minute time windows. This plot over time was investigated for changes at the time of ship arrival. There is good representation of ship noise if *L95* increases at the time of berthing.
2. For short-term mobile measurements in comparison to continuous noise measurements: *L95* spectra were evaluated in 1/3 octave resolution. If these spectra increase significantly for one single location there is a high possibility that a continuous local source like a reefer truck was present in the vicinity of the microphone.

[1] ISO 1996-2:2017, Acoustics — Description, measurement and assessment of environmental noise

3.1.3 Consideration of noise propagation

In practice, atmospheric noise propagation is composed of multiple transmission paths of which the most relevant ones are direct path and bottom reflection as shown in Figure 2. In the low frequency range these two paths interfere positively and negatively, depending on wavelength and measurement geometry. The graph shows results for boundaries of the measurement campaign in Warnemünde: Distances were roughly between 30 m and 300 m. It is possible for all measurement geometries that low-frequency noise from the diesel engines below 100 Hz is altered by wave overlap of the two propagation paths. With the microphone positioned in this location, it can be observed that the measured level of exhaust noise is very low. The source level and the prediction of received noise in the residential area can be underestimated. For this reason, frequency-dependent propagation is taken into account individually for every measurement location. For practical reasons the ship was simplified as a point source and all noise is assumed to originate from the exhaust pipe opening. The distance between microphone and exhaust pipe was measured optically.



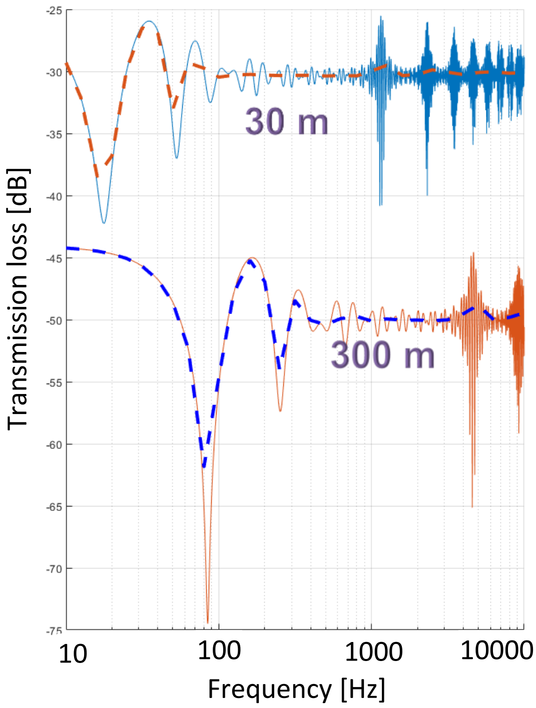


Figure 2: Schematic sketch of noise propagation (left) and examples for frequency-dependent transmission loss (right), plotted for 6 m microphone height and 40 m source height over quay. Comparison of narrow-band and 1/3 octave average.

3.1.4 Prediction of received noise in the residential area

The noise monitoring system for ship noise shall provide an estimate of received levels in the residential area. Measured levels of a microphone at the terminal shall be translated to this location by individual transmission loss *TL*. This is made in two steps:

1. Calculation of source level *SL*, taking into account the distance between microphone and source
2. Calculation of received level *RL*, taking into account distance between noise source and receiver location

$$(1)\ SL = RL_{Terminal} + TL_{Terminal \rightarrow Source}$$

$$(2)\ RL_{Receiver} = SL - TL_{Source \rightarrow Receiver}$$

The transmission loss is calculated in narrow bandwidth and averaged in 1/3 octave bandwidth. All following calculations according to Figure 3 are made in 1/3 bandwidth. A processing routine for common evaluation of all three data sets was developed in the framework Matlab ®.

For the situation with two berthing ships each measurement was translated both to berth P7 and berth P8. However, it is not possible from the recorded data of one single microphone to identify whether the noise floor originates from P7 or P8. Therefore, identification is made by comparison of multiple positions.

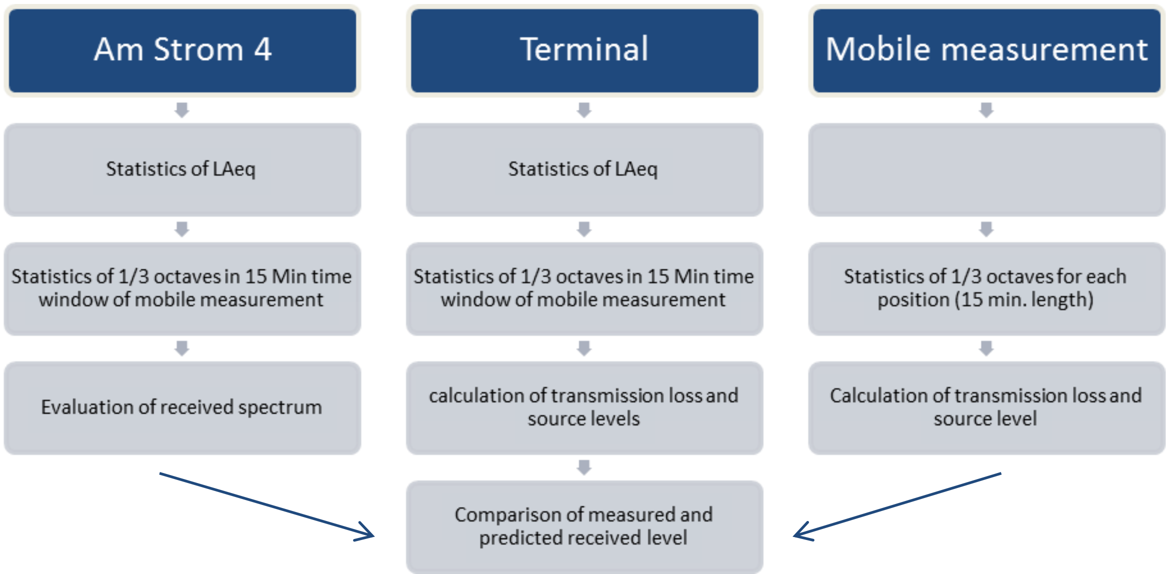


Figure 3: Structure of data evaluation for three measurement positions

3.2 Determination of noise immission

The continuous measurement station at the location *Am Strom 4* was evaluated for content of ship noise.

3.2.1 Measurement noise floor *L95* over time

The noise floor can be examined in the statistics presented in Figure 4. The noise floor is represented by the L95 value. It is almost constant at the continuous measurement location "Am Strom 4" after the cruise ship's arrival at about 07:00. In contrast to this, the noise floor further increases at the continuous measurement location "Terminal" after both ships arrived at berth and reaches its peak about two hours later.

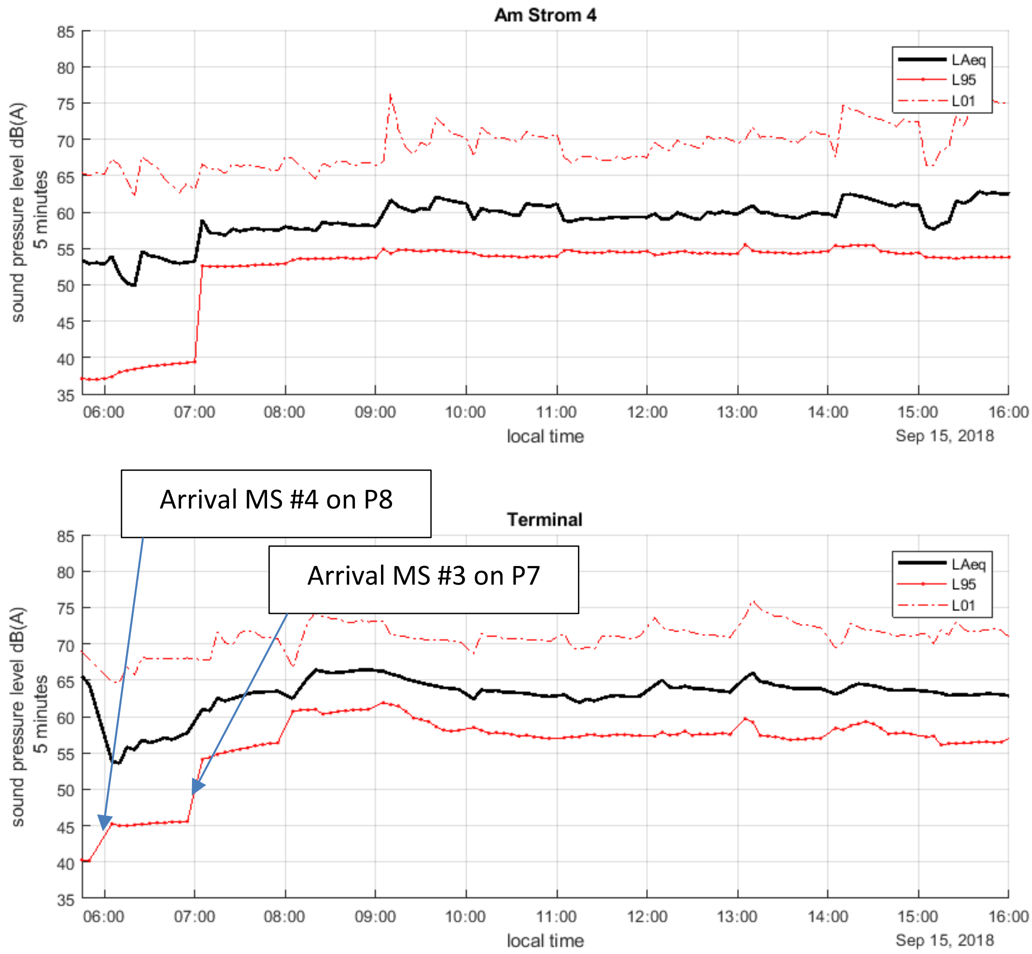


Figure 4: Evaluation of broadband levels over time for two measurement locations.

3.2.2 Additional components of rating levels

A complete evaluation with respect to regulation "TA Lärm" requires determination of disturbing sounds (see section 2.1). These parameters were not evaluated in this project for different reasons:

1. Impulsive sounds are not contained in the *L95* which provides the basis for identification of ship noise
2. Identification of tonal noise is technically possible but requires high additional complexity in data evaluation
3. Low-frequency noise must be evaluated by indoor measurements which were not possible in this project

4. Evaluation of Information content is not possible on the basis of *L95*

The evaluation contains only *LAeq* levels under the assumption of a ship berthing in the full daytime period between 06:00 to 22:00.

3.3 Collection of emission levels

The emission levels were calculated on the basis of *L95* 1/3 octave spectra. The overall sound power level was calculated from the energetic sum of the spectrum. Sound power levels of each ship were calculated from the data of mobile measurements and continuous measurements. The transmission paths of each measurement location were taken into account. From the resulting sound power levels, outliers were identified. The remaining sound power levels were averaged and are presented in chapter 5.3.

4 Measurement

4.1 Setup and measurement locations

The data was recorded with mobile sound levels meters. These recorded audio data and processed all necessary broadband levels and 1/3 octave spectra on board in resolution of 1 second. Continuous measurements were made with *Norsonic Nor140* analysers, mobile measurements were made with an *NTi XL2* device. All equipment was *DAKSS* calibrated.

To determine noise emission of the cruise ships, the measurements were conducted onshore at the terminal area. These locations were chosen with respect to organizational reasons, i.e. to reduce disturbances of the onboard operation and to minimize the measurement effort.

An aerial overview of the measurement locations is provided in Figure 5, the locations at the terminal with respect to receiver locations are compiled in Figure 6.

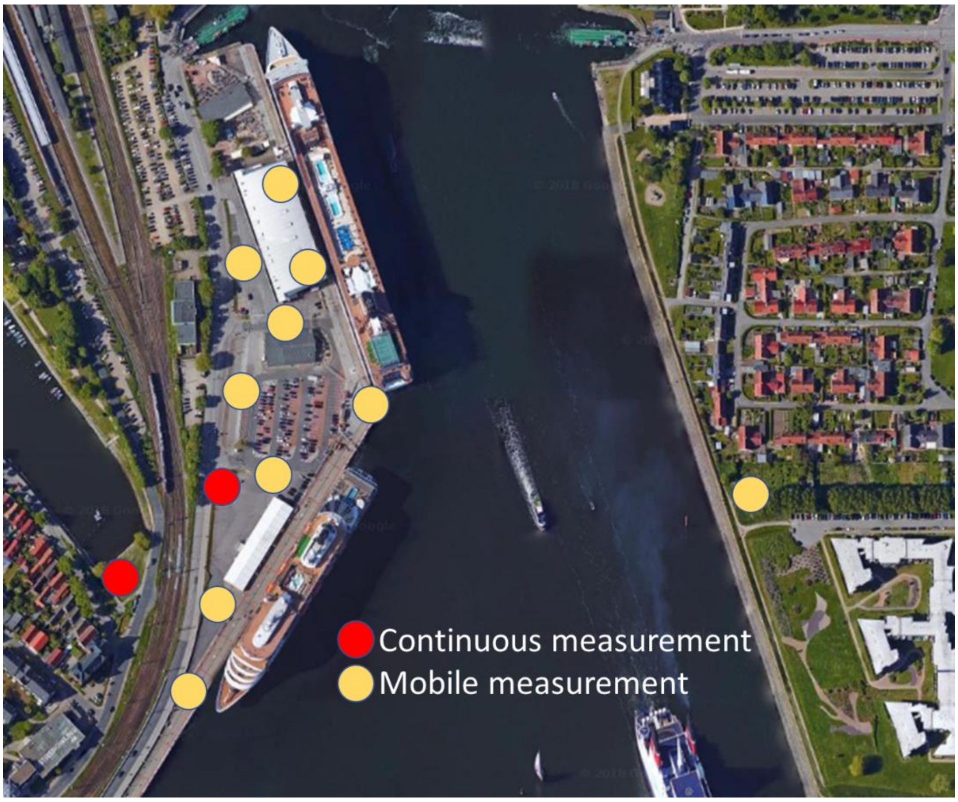


Figure 5: Aerial view of the measurement locations.

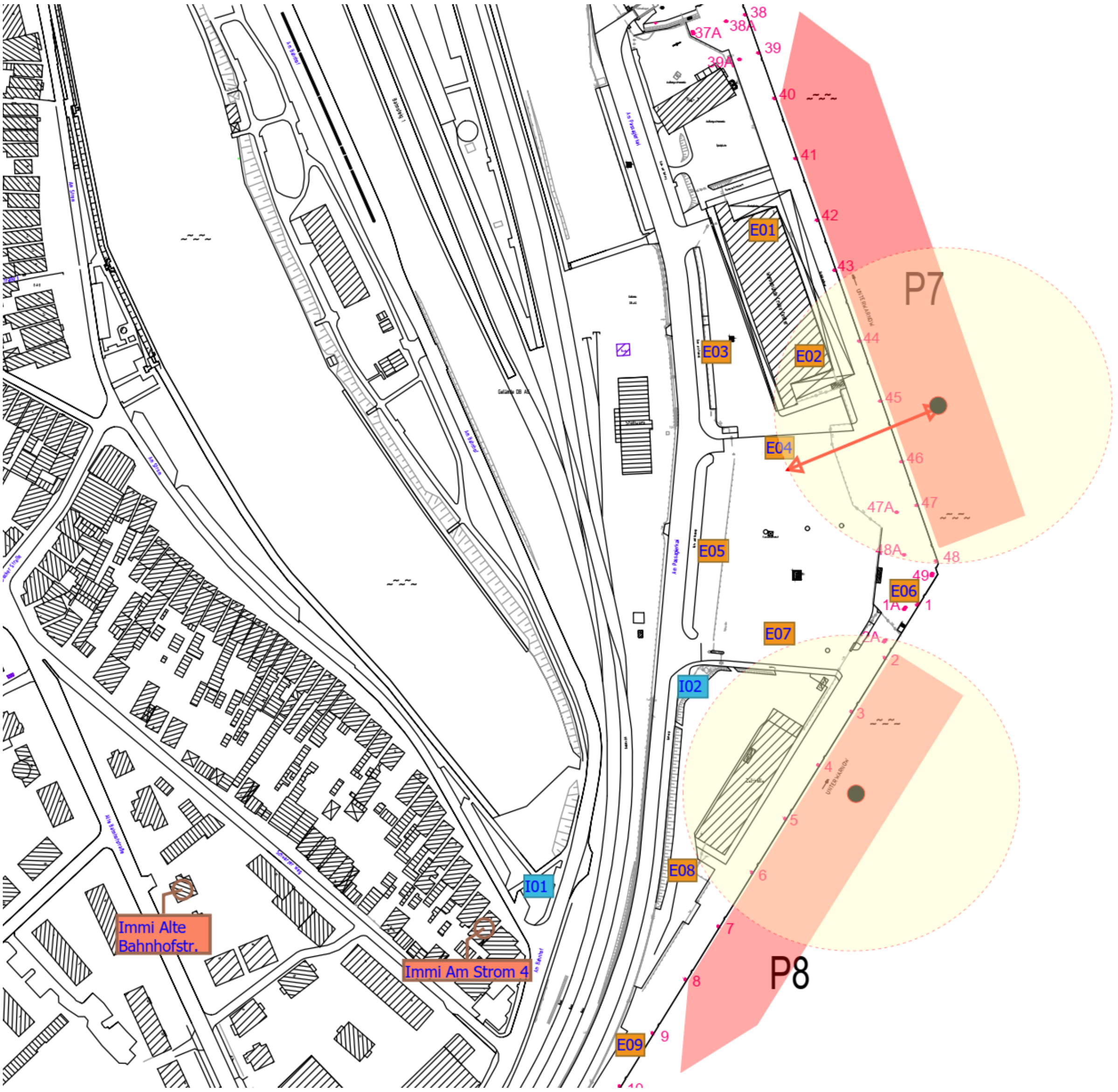


Figure 6: Locations of mobile measurements (red, prefix 'E') and continuous measurements (blue, prefix 'I') in comparison of relevant receiver location in the residential area.

4.2 Selection of cruise ships

There were nine ships in total present during the measurement campaign at two weekends. Ship names are anonymized and listed in Table 1. Ship MS #1 und Ship MS #3 visited Warnemünde at both weekends.

Table 1: Ships at berth during noise measurements in Warnemünde.

		Berth P7		Berth P8	
Fri	14.09.	07:00-21:00	MS #1	08:00-22:00	MS #2
Sat	15.09.	07:15-18:30	MS #3	06:30-22:00	MS #4
Sun	16.09.	08:30-21:00	MS #5		
Sat	22.09.	07:30-18:00	MS #3	05:45-20:00	MS #6
Sun	23.09.	11:30	MS #7	07:00-20:00	MS #1

4.3 Environmental conditions

Environmental and meteorological conditions were recorded by a DWD weather station nearby and are presented in Table 2.

Table 2: Environmental conditions recorded by DWD weather station in Warnemünde.

Date	Wind speed average	Wind direction average	Atm. pressure average	Air temp. Average	rel. humidity average
	[Bft]	[°]	[hPa]	[°C]	[%]
14. Sep	2	226	1017	17	56
15. Sep	4	256	1018	16	70
16. Sep	3	207	1021	18	58
22. Sep	4	231	1011	13	73
23. Sep	3	241	1009	12	78

5 Results

5.1 Feasibility of a Monitoring concept

The idea of a noise monitoring system originated from observations that a subgroup of cruise ships can induce exceedance of mandatory noise immission limits. Most relevant receiver locations are located in residential areas close to the terminal where the rating level of 55 dB must not be exceeded during daytime when cruise ships are moored at berth. There is currently no tool available for terminal operators to evaluate the current acoustic situation. In case of complaints the operator is typically informed with delay so that mitigation measures cannot be applied right away after arrival of a noisy ship. It is therefore desired to improve the response time in case of potentially disturbing acoustic situations.

For logistic reasons the installation of the noise monitoring system is preferred at locations at the terminal. In comparison to locations in the residential area the terminal site is better protected against unauthorized access, furthermore the flexibility for selection of locations is greater. However, for a monitoring system at the terminal there is an in creased technical complexity expected because the measured values must be translated to received levels at relevant immission points. In this respect the noise monitoring system faces several challenges which are roughly grouped in “geometrical accuracy” and “logistical suitability”. In the context of this report it is assumed based on discussions with the contracting authority that the noise monitoring system is to be developed especially for monitoring of ship noise. Other contributions from the terminal like delivery traffic and terminal logistics (forklifts, cranes) are less relevant.

The “logistical suitability” of a monitoring position described whether there is sufficiently low contribution from other local noise sources in vicinity of the microphone so that purely noise from cruise ships is audible in some periods of time. For example, a locations close to a heavily frequented road would not be logistically suitable due to permanent masking of ship noise.

The “geometrical accuracy” is structured in several subtopics

- The distance between measurement system and noise source must be known with sufficient accuracy. This is particularly challenging in times when two cruise ships are moored at berths P7 and P8.
- Uncertainties in noise propagation from baffling and directivity of sources must be avoided as far as possible
- The monitoring location must be located sufficiently far away to take into account that many positions of noise sources on board are inaccurately known. Ventilation fans are distributed over a wide area on board. The relative errors due to this uncertainty decrease with increasing measurement distance

All factors affect the achievable accuracy of a prediction of immission levels based on measurements at the terminal site. In this project, the accuracy of 10 locations is evaluated by means of a comparison of measured immission at the location “Am Strim 4” with the prediction from mobile measurement locations and with permanent measurements at the entrance of the terminal. An example of this comparison is shown in Figure 7. Each group of three differently coloured bars is compiled for the period of time of a 15 minutes long mobile measurement. The L95 noise floor from this time frame was calculated for all datasets. Received levels were predicted based on the terminal measurements by geometrical noise propagation.

From the comparison two aspects are observed:

- Blue bars from mobile measurements in comparison to grey bars describe geometrical suitability of a mobile measurement location
- Fluctuations of orange bars indicate that L95 noise floor is contaminated by local noise sources other than the ship.
- It must be taken into account that for situations when one ship is much noisier that the other an evaluation is only possible for the noisy ship. The quieter one is masked at most locations.

The most suitable monitoring location is identified by the least differences between grey bars and coloured bars in Figure 7. A summary for comparisons of all measurement days is compiled in Table 3. It results that two separate monitoring locations are recommended: E07 for berth P7 and E09 for berth P8. However, the location P7 is expected to be logistically rather unsuitable, therefore E04 is identified as reasonable alternative. We recommend precise observation of terminal activity to further investigate logistical suitability.

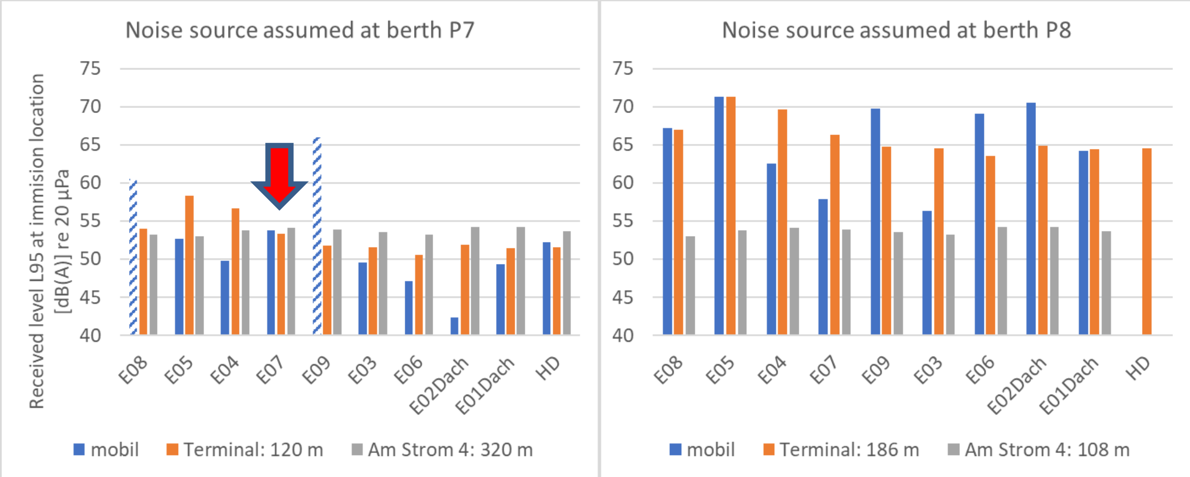


Figure 7: **Comparison for suitability of measurement locations. Dominant noise source located at berth P7, 15.09.**

Table 3: Identification of mobile positions with least tolerance in comparison to immission measurement.

Date	Prediction for P7	Prediction for P8
14.09.	E05	E09
15.09.	E07	Not dominant
16.09.	E04	No ship at berth
22.09.	Not dominant	E09
23.09.	E07	Not dominant

5.2 Noise immission

The results of received noise levels in the residential area due to presence of the cruise ships (as shown in chapter 3.2) are summarized in Table 4.

Table 4: Measured *L95* levels with and without cruise ship present

Date	Noise floor before arrival	Berth first ship	Berth second ship
14.09.	40 dB(A)	45 dB(A) Sailing of MS #2, P8	52 dB(A) Sailing of MS #1, P7
15.09.	37 dB(A)	39 dB(A) Berthing of MS #4, P7	53 dB(A) MS #3 an P8
16.09.	38 dB(A)	45 dB(A) MS #5 an P7	none
22.09.	41 dB(A)	42 dB(A) MS #6 an P8	50 dB(A) MS #3 an P7
23.09.	38 dB(A)	50 dB(A) MS #1 an P8	No increase due to presence of MS #7 an P7

The table shows that the TA Lärm limit values for residential areas (55 dB(A) at day time) are not exceeded. The berthing of the first ship leads to an increase of the immission levels of 2 to 12 dB(A). The overall noise level with both ships berthed does not exceed 53 dB(A) and is therefore below the TA Lärm limit value. Please note that the noise floor before arrival was taken during morning or night time. This noise floor would also increase considerably during day time if no cruise ships are at berth. The surcharges according to TA Lärm are not taken into account here and could lead to exceed the limit value (see chapter 2.1 and 3.2.2).

5.3 Emission levels

The calculated sound power levels of the cruise ships at berth are shown in Figure 8 as broadband levels and in Figure 9, Figure 10, Figure 11 and Figure 12 as spectral levels. In the graphs, the spectral representation is grouped by cruise ship classes.

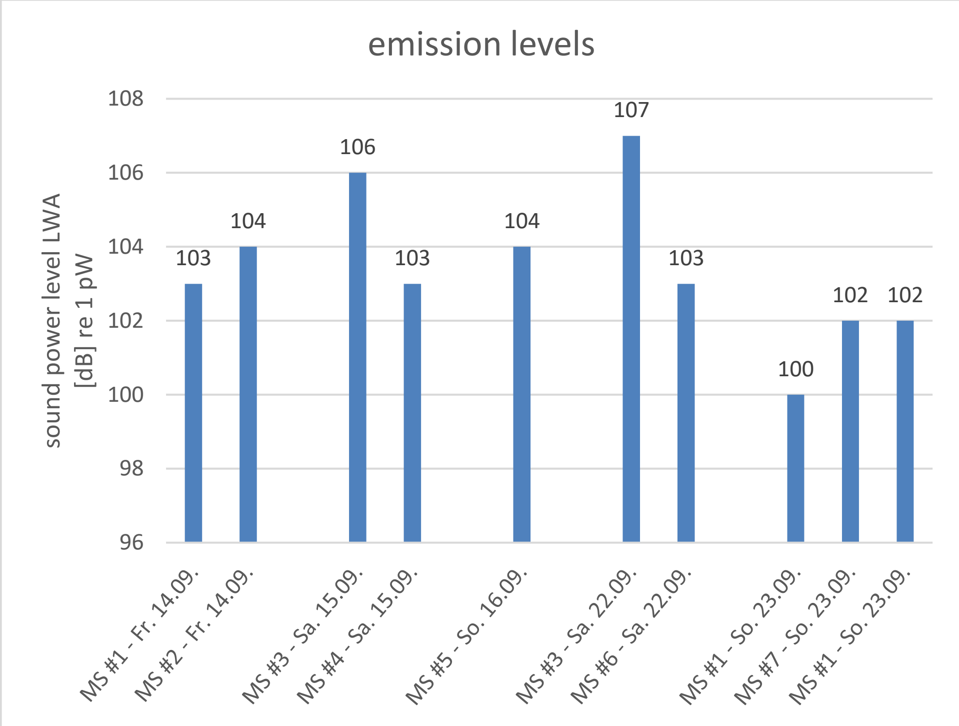


Figure 8: Resulting broadband levels of emission measurements.

Figure 8 shows the different ship sound power levels which vary between 100 dB and up to 107 dB re 1 pW. The differences are within the range of expectation as the ship types and engine types are different.

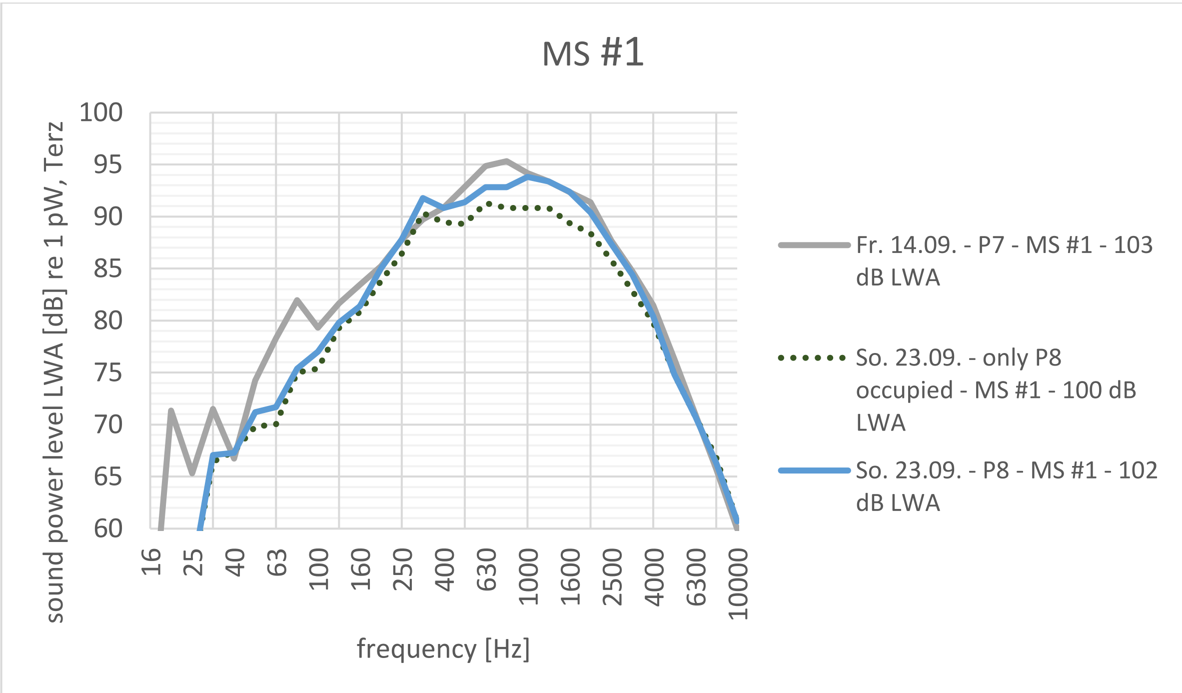


Figure 9: Third octave sound power spectrum of MS #1.

Figure 9 shows one ship in three different conditions. Only the dotted graph shows the ship with no other cruise ship in vicinity. If another ship is present the measurement data of the quieter ship (in this case MS #1) is slightly increased in value, as the noise of the other ship adds up the MS #1 source level. MS #1 is the quietest cruise ship of this study.

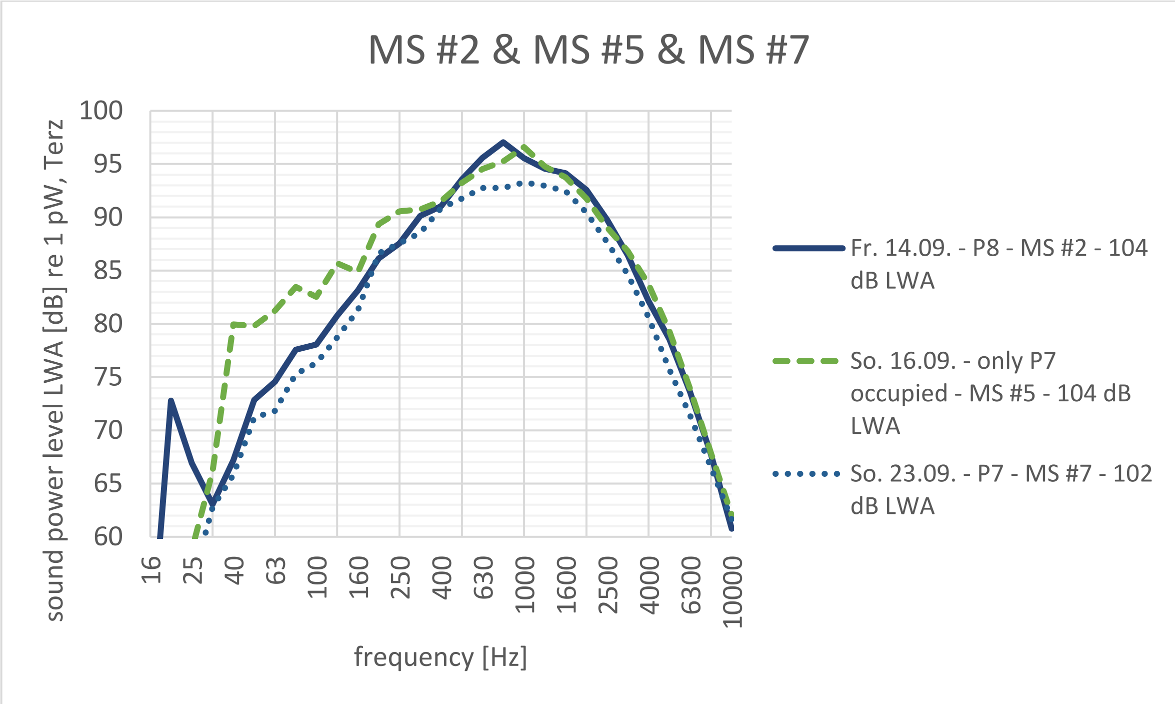


Figure 10: Third octave sound power spectrum of MS #2, MS #5 and MS #7.

Figure 10 shows three ships of one specific type. The graphs show that even similar ships are different in terms of their emitted noises. They could use different auxiliary engines and engine room fans or even differ in noise insolation. Also variations of the measurement environment (weather and external noises) may have minor influences on the measurement data.

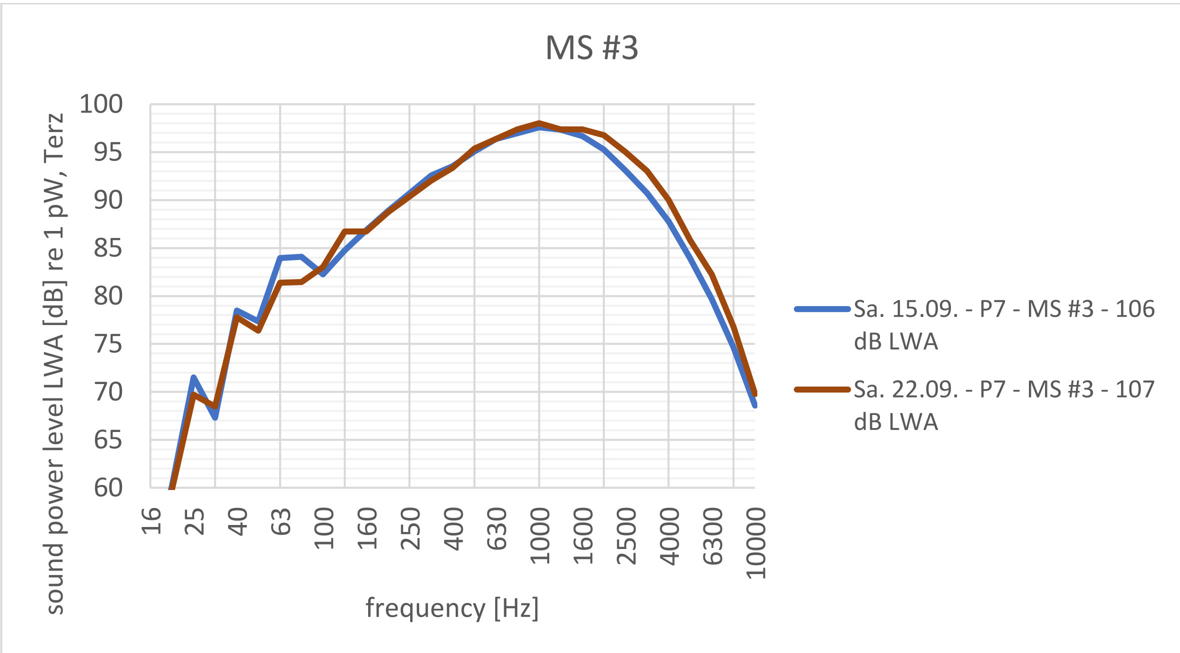


Figure 11: Third octave sound power spectrum of MS #3.

Figure 11 shows the loudest ship of this study. It was not as much influenced by the presence of other cruise ships in vicinity, therefor the graphs are similar.

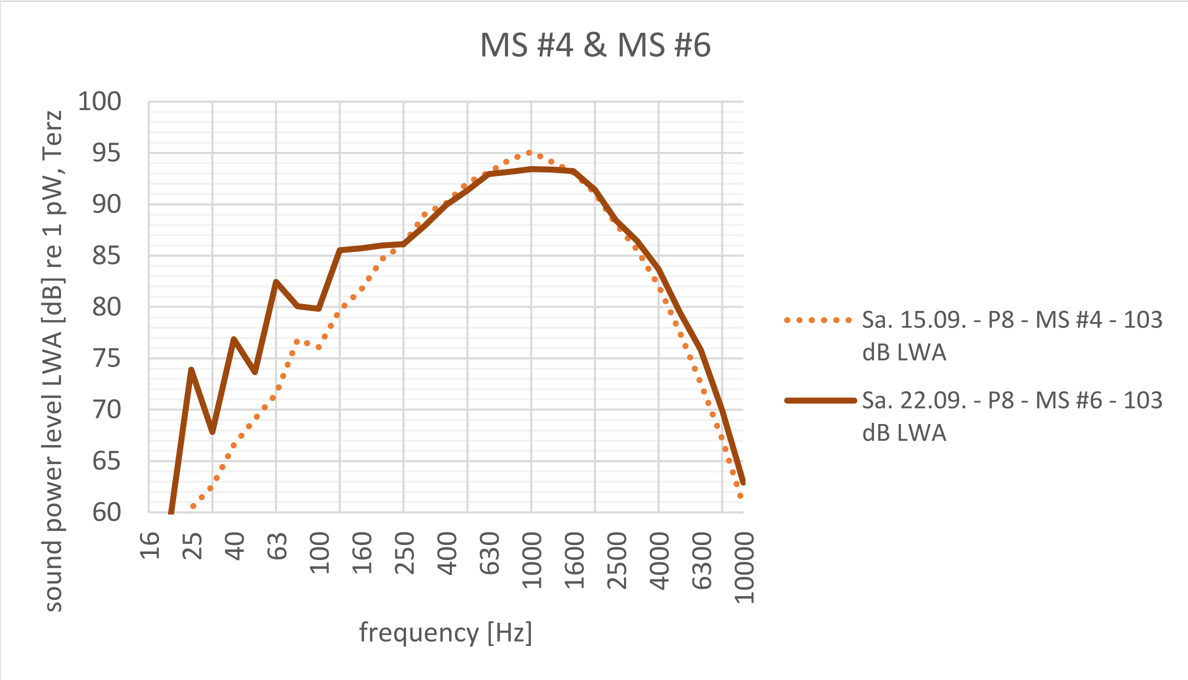


Figure 12: Third octave sound power spectrum of MS #4 and MS #6.

Figure 12 shows two ships with the same LWA but different spectral deviation. MS #4 seems to have louder fans compared to MS #6 which has louder auxiliary engines.

Overall the spectral analysis shows the dominant sound bands between 500 Hz and 1600 Hz. This could mean that the engine room fans are the dominant source of these cruise ships or that lower frequencies are underrepresented. The latter may be caused by bottom reflection or the extinction of waves in lower frequencies due to the inhomogeneous noise propagation due to buildings.

Compared with data from an influence of a louder ship on a quieter ship we estimate the overall deviation from the given LWA of about +/- 3 dB(A). This is supported by other studies not been published jet and the experience of DW-ShipConsult.

6 Conclusion

This study summarizes procedures for measurement and analysis as well as results of noise measurements in the cruise port of Warnemünde. The measurement campaign was designed to evaluate feasibility and accuracy of a noise monitoring system at the terminal site with respect to assessment of noise immission in surrounding residential areas. All measurements were conducted on shore side since access to the ships was not available.

The measurement setup consisted of three measurement locations of which two remained stationary during all activities. The third device was applied for short periods of time at different locations to evaluate suitability of these locations for monitoring purposes. The recorded data was analysed with respect to three different questions:

1. Feasibility and achievable accuracy of a monitoring system
2. Assessment of noise levels at the relevant immission location “Am Strom 4”, rough quantification of rating levels
3. Collection of emission levels by means of source power spectra of the cruise ships at berth

The monitoring system faces several challenges of which source separation is deemed one very important aspect. The measured noise levels at the terminal site are composed of many contributions from sources in different distances. From this mixture, the contribution of the ships must be separated to predict received levels from ship noise in the residential area. In the port of Warnemünde the identification of continuous ship noise was implemented by statistical analysis of the noise floor. This concept proved well in most situations as long as the cruise ships at berth were the only dominant continuous noise source in the area. Periods of time with continuously running cooling trucks or busses needed to be excluded from the analysis. This aspect should be considered for transfer of this monitoring concept to other cruise ports where dominant continuous noise from roads or industrial activity might be present. The most suitable locations for a noise monitoring system to predict received levels at the location Am Strom 4 were found at the fence facing a small road at the shore western edge of the terminal. These locations were sufficiently far away to avoid confusion from baffling, from imprecisely assumed source locations or from directivity of sources.

The feasibility and expected accuracy of a noise monitoring system was investigated. The objective of the monitoring system is the prediction of received noise levels in residential areas based on measurements at the terminal site. The locations at the west side of the terminal area proved to have the lowest tolerances of approximately +/- 3 dB. The evaluation of *L95* proved reliable as long as there are small time gaps in traffic at the terminal site. Only for some very busy time windows, the *L95* was useless due to continuous presence of disturbing noise sources such as trucks, busses, etc.

On the basis of the estimated emission levels of cruise ship at berth, it should be attempted to draw conclusions about immission levels. Therefore, noise immission for the location *Am Strom 4* was investigated for contribution of cruise ships and for comparison with the predictions. It was determined that without any cruise ship present the average level was just below the required rating level of 40 dB. The increase of *L95* noise floor due to presence of ships amounted up to between 45 dB and 53 dB. This was evaluated for moment shortly after arrival of the ship. Overall, the immission results are below the 55 dB daytime threshold according to TA Lärm. The numbers do not include contribution from other business in the area. By the described L95 method the additional factors for impulse content, tone content and information content cannot be calculated as only the noise floor is regarded. Determination of these additional factors appear challenging due to the influence of other noise sources such as terminal operation, traffic, etc. Obviously, a measurement location outdoors does not allow for conclusions to low frequency additional levels, because the TA Lärm describes indoor measurements at the immission location as obligatory. Although the gained immission levels were gained by the L95 method, which is not described by the TA Lärm, it is assumed that these levels can be compared qualitatively to the rating levels of TA Lärm as the L95 method describes only the stationary noise immission which is prone to result from the cruise ships.

In this study a variety of land-based measurements was conducted to determine noise emission levels of cruise vessels. The simplification of the ship to a point source and the distance to the source (measurement takes place on the Terminal and not near to the source itself) shows the potential for accuracy challenges. Uncertainties in the over/underestimation of emission values in the order of +- 3 dB caused by transmission loss assumptions and simplifications of the source were achieved. The derived broadband levels for sound power *LWA* of the cruise ships (100 dB to 107 dB re 1 pW) are in the range of literature values (reference to sources not being published yet). Also, the results are similar to experiences of DW-ShipConsult. The gained results of broadband and spectral distributed levels can be further used in noise propagation models and noise map calculation.

In summary, the approach presented shows potential for estimating the permanent contribution of a cruise ship to the immissions at critical immission values and for supporting the terminal operator in his argumentation with residents and authorities. Showing sufficient accuracy for noise immission evaluation, the presented concept can be realised in a lean and cost-efficient way. The general idea of the approach can be transferred to any Baltic Sea port while the spatial situation of each port has to be taken into account. In the sense of a traffic light system, the system can support the terminal operator in limiting cruise noise emissions immediately if threshold values are exceeded. Furthermore, the shown emission results for cruise ships are general information for any Cruise Terminal and thus useful for estimation of other noise concerning the Baltic sea.