



Tystgående citydistribution för nattleverans i Stockholm Stad

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Summary

This study has been focussed on one of the critical enablers for night time delivery in cities, also called Off-peak or Off-hour delivery, which is noise related to the transport as such. Noise generated by a transport, may be divided in two main categories, one related to the movement and operation of the vehicle in itself and one to the handling of the goods at the site of delivery. Both has to be considered and controlled in order for an Off-peak delivery scheme to be set up, operated and in the end tolerated by people living in the city. At the same time, the overall transport efficiency must be carefully controlled in order to provide a balanced solution.

In this study the most critical sources of noise, from both categories, have been reviewed and possible modifications have been identified for later implementation in a parallel activity.

It is a well-known fact that the power train, is one of the most critical components with respect to noise under city driving conditions. Hybrid solutions, with electric-diesel/gas configurations, offer a potential solution to the problem of noise generated while driving. However, the optimal configuration from a total energy point of view is not obvious as energy for auxiliary systems, such as cooling and brake systems, also need to be balanced.

The current study has involved researchers from KTH, with inputs from Scania.

General project description and background

This study has been focussed on the noise generated by a transport operation as one of the critical enablers for night time delivery in cities, also called Off-peak or Off-hour delivery. For this purpose the noise emission, categorised from a source point of view, may be divided in two main categories, one related to the movement and operation of the vehicle in itself and one to the handling of the goods at the site of delivery. Both has to be considered and controlled in order for an Off-peak delivery scheme to be set up, operated and in the end tolerated by people living in the city. At the same time, from a sustainability point of view, the overall transport efficiency must be carefully controlled in order to provide a balanced solution.

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The concept of Off-peak delivery carries a radical change in the optimal cross-functional conflict balance related to efficiency and emissions of noise. As most of the natural sources of masking noise are reduced or completely absent at night time, the spectral and temporal properties of the noise specific to the actual transport vehicle movement and operation, come into focus. As an example, it could be expected that low frequency noise, tonal components as well as transients will be the critical elements for a positive subjective assessment.

Apart from changing the optimal balance point, this could possibly require a new focus on low frequency noise. Current regulations use the A-weighted dB scale, which is placing less emphasis on the lower frequency parts of the spectrum. However, as the subjective evaluation of the noise produced in the end will determine the success of Off-peak as a concept, this could also force a change of the weighting of the objective measurements in order to better match the actual experience.

In the following, a brief overview of the most important noise sources will be given first. This serves as the pre-cursory to a series of planned modifications of some of the trucks that will be involved in the Off-peak delivery study that is currently on-going in Stockholm. Note that the most stringent requirements on the emitted noise are enforced within the city limits, while the phases related to driving back and forth from possible storage hubs can be relaxed in terms of noise emissions. The report then gives a brief qualitative overview of the functional requirements and possible modifications to an existing truck that then would meet those and be eligible for Off-peak delivery service.

The work within this prestudy has been conducted as a series of workshops and is based on preliminary experience from the Off-Peak research project, financed by FFI and hosted by KTH-ITRL.

This prestudy is a preparation to a larger research effort aiming at identifying sources and improvements on the trucks involved in the field test of Off-Peak project.

Achieved results

Inventory of Noise sources

A first workshop was held focusing on inventory of noise sources. The following sources were considered to be the most important.

Vehicle driving

- Power train: engine, gearbox, cooling fans
- Exhaust system: idling, spectral contents at low rpm
- Road/tire interaction: tire profile, road surface
- Aerodynamic noise

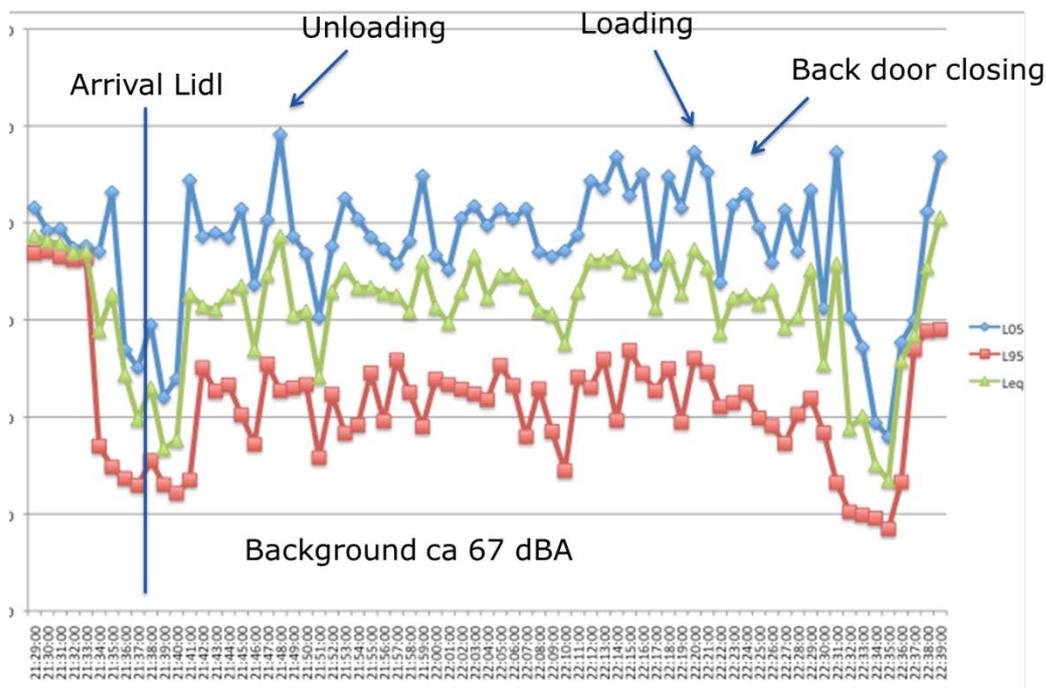
Vehicle at delivery site

- Loading and off-loading: Ramp, goods carts, cages, forklift, hand pallet trucks
- Hydraulic lifts: pumps
- Brake system: pneumatic valve release, pumps
- Cooling fans
- Warning systems

Field measurement examples

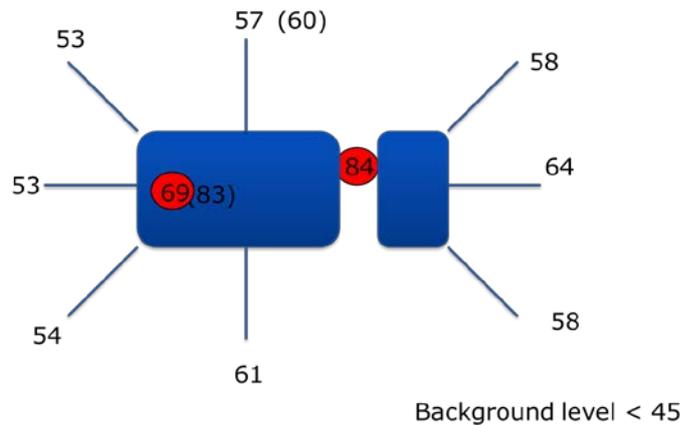
Field data has proven that noise levels from loading and unloading work, as the vehicle is at delivery or pick-up site, seem to be the most difficult to address and may also be causing the most disturbance due to being variable and irregular causing disturbance. During driving, recorded data show a stable but rather high level of noise generation, strongly coupled all 4 factors mentioned above. To sort out the individual levels, well-controlled experiments need to be conducted.

Below is presented an image of typical noise generation as measured at the source (mic placed at the rear of the vehicle) from the Off-Peak field tests during a typical loading/unloading sequence during a night delivery in central Stockholm:



In order to define and identify suitable maximum source levels it is important to conduct a noise field mapping. It relates the source to the experienced noise level at a distance from the source. The transfer from source to field is affected by many parameters, such as vehicle geometry and exterior materials as well as surrounding

environment. A preliminary field mapping was conducted in a well-controlled (quiet) outdoor open environment for one of the Off-Peak trucks running on idle with the diesel engine. See results below.



As can be seen in picture above, the transmission from the source to field varies around the vehicle with the lowest levels behind the truck. The red spots indicate placement of the on-board microphones used to log noise data in the off-peak project, and the levels recorded in this preliminary test.

One conclusion is that it is important to develop a well-defined noise transfer function (specific for each vehicle) in order to analyze experimental results from the perspective of city noise levels. That work is not within the scope of the present prestudy.

Functional requirements enabling Off-peak delivery

A major challenge in the introduction of Off-peak delivery systems, is the low background noise level at night and the corresponding lack of masking of the noise generated in the various parts of the transport movement. As a basis for the functional requirements related to the noise emitted by a truck that would be qualified for Off-peak transport missions, as a minimum the PEAK norm should be met by all equipment involved in the delivery chain, starting from the entry into the inner city limits. Unfortunately this does not guarantee that the perceived annoyance will be kept at an acceptable level, but certain critical aspects of the noise spectrum and the temporal characteristics must be investigated and ultimately controlled as well. In particular, transients and intermittent noise are more annoying than the actual equivalent noise level would indicate. Low frequency noise together with possible tonal components must be identified and modified as far as possible.

As part of the on-going parallel activities within the Stockholm Off-peak study, these will be studied in some detail together with different measures for the equivalent noise emission of a certain transport mission. If possible narrow band measurements could also be conducted inside and outside of an apartment to get a better understanding of the noise transmission problem.

Suggested adaptations and modifications to meet functional requirements

Continuous charging

To avoid transients related to charging of batteries and pneumatic brakes etc., a possible solution could be to have a continuously running small, low rpm diesel engine. If required, the engine could be switched off inside the city limits.

Shielding of sources

Various types of more or less absorbing shields could be installed to reduce the noise radiated from: cooling fans, power and drive train components, under body treatments, engine compartment, etc.

Exhaust system

Tuning of the mufflers to low rpms for combustion engines.

Operational restrictions

The maximum rpm could be set to about 1400 rpm.

Maximum allowed acceleration and torque.

Cooling fans only run outside of the city limits.

Timing and finance

The prestudy is the result of work conducted over the period Jan 2015-June 2015.

The total budget for the prestudy project is 300 kSEK , of which 180kSEK is funded by SHC.

Executors and collaboration

The work has been carried out as workshops and collaborations between KTH, and Scania, with input from Svebol Logistics (Martin Svedin) and Stockholm Municipality (Trafikkontoret), Erik Levander.

The main researchers are Prof. Peter Göransson (KTH), and Assoc.Prof. Ragnar Glav (Scania).

Dr. Peter Georen has been coordinator and has contributed with result-examples from the Off-Peak project to the report.

This prestudy is strongly connected, and prepares, for a larger effort with FFI project *Off-peak citylogistics* that is active during the period 2015-2016 in Stockholm with partners from: KTH, Chalmers, Stockholm Municipality, Svebol, Martin&Servera, Volvo and Scania.

Dissemination of Results

The results of this prestudy will be disseminated to the "mother-project" consortium and later also, as part of research results, presented at suitable conference or scientific publication.

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