# Annoyance due to single and combined sound exposure from railway and road traffic

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Environmental noise is a growing and well recognized health problem. However, in many cases people are exposed not to a single noise source – for example, road, railway, or aircraft noise – but to a combination of noise exposures and there is only limited knowledge of the effects on health of exposure to combined noise sources. A socio-acoustic survey among 1953 persons aged 18-75 years was conducted in residential areas exposed to railway and road traffic noise with sound levels ranging from LAeq,24h 45-72 dB in a municipality east of Gothenburg, Sweden. The objectives were to assess various adverse health effects, including annoyance, and to elucidate the impact of exposure to single and combined noise sources. In areas exposed to both railway and road traffic, the proportion annoyed by the total traffic sound environment (total annoyance) was significantly higher than in areas with one dominant noise source rail or road traffic with the same total sound exposure (LAeq,24h,tot). This interaction effect was significant from 59 dB and increased gradually with higher sound levels. Effects of the total sound exposure should be considered in risk assessments and in noise mitigation activities.

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## 1. INTRODUCTION AND AIM

Community noise is an environmental stressor with documented short-term effects (e.g. annoyance, interference with speech communication, and disturbance of sleep and rest) and long-term consequences for health and well being (WHO, 2000; Öhrström, 2004). In contrast to many other environmental problems, noise pollution is still growing. In residential areas, road traffic is normally the dominant noise source; and road traffic in Sweden has been predicted to reach 120-130% of 1997 levels by 2010 (SIKA, 2000, 2002). A meta-analysis conducted by Miedema and Oudshoorn used results from large data sets to examine the relationship between annoyance and exposure to noise from a single source (road traffic, aircraft, or railways) (Miedema and Oudshoorn 2001); the analysis showed that road traffic noise causes more extensive annoyance reactions than railway noise, and so a "bonus" of 5 dB has been applied to railway noise in most European Union (EU) countries, e.g. Austria, Germany, France, Switzerland, and Sweden (EU Commission 2002). Some of the more recent studies on railway and road traffic noise, not included in the meta-analysis by Miedema and Oudshoorn (2001), show no support for a railway bonus (e.g., Kaku and Yamada, 1996; Yano et al. 1998; Lercher et al., 1999; Kurra et al., 1999; Morihara et al., 2002) while other studies (Lambert et al., 1998; Moehler et al., 2000; Vos 2004) give support for a railway bonus.

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Although a large part of the population is exposed to environmental noise from more than one source, there is little knowledge of the relationship between annoyance and noise exposure when more than one noise source is present. There is no standardized or commonly accepted method for assessing the total noise impact from combined sources, although several models have been proposed, such as the energy summation model and the dominance model (Ronnenbaum et al., 1996; Nilsson, 2001; Miedema, 2004).

Only a few larger studies have investigated annoyance from multiple noise sources. Ronnembaum et al. (1996) found support for the dominance model in their analysis of data from a large German study involving 1740 respondents exposed to road traffic and railway noise. In areas with one of the two sources dominant, annoyance due to this source exceeded total annoyance, which in turn exceeded annoyance due to the other source. Joncour et al. (2000), Cremezi et al. (2001), and Champelovier et al. (2004) presented results from a French study performed in 1997 involving 62 study sites exposed to both road traffic and railway noise. In total, 664 people were interviewed: 126 in railway dominated sites, 282 in road traffic dominated sites, and 256 in sites with no single dominant noise source. Sites were defined as "railway dominant" or "road traffic dominant" if the difference in sound level between the two sources was larger than 5 dB. The results gave some support for the dominance model. The probability of being disturbed by railway noise increased with increased sound level. A potential interaction was observed between annoyance due to railway traffic and annoyance due to road traffic; however, this interaction was rather complex, making it difficult to draw any firm conclusions on interaction effects. There is, then, a need for further studies on the health effects of multiple noise sources, and further consideration of ways to handle noise exposure from more than one source at a time.

A large socio-acoustic survey was conducted in 2004 among people ($n=1953$) living in residential areas exposed to road traffic noise, railway noise, and also to some extent aircraft noise ($L_{\mathrm{Amax}}$ levels below 70 dB) in the municipality of Lerum, east of Gothenburg, Sweden. The aims of this survey were to assess the prevalence of short-term and long-term health effects of noise exposures, to develop a method for determining individual noise exposure based on geographical information systems (GIS) techniques and to examine and propose new indicators suitable for following up the prevalence of health-related effects of traffic noise. The main results (see main report Öhrström et al., 2005a, 2005b) demonstrated extensive, dose-related effects of noise in terms of annoyance, activity, and sleep disturbances, as well as stress-related psycho-physiological symptoms. Among men, particularly those who had lived in their present homes for more than 10 years, the incidence of hypertension and use of hypertension medication increased with increasing road traffic noise.

This article presents results from this survey on general annoyance resulting from road traffic noise, railway noise, and the total traffic sound environment. Noise exposure was calculated for railway and road traffic separately, and the energy summation model was applied to assess the total noise exposure from road and railway traffic. Noise annoyance was assessed with separate questions for the two main noise sources and for the total traffic sound environment.

## 2. MATERIALS AND METHODS

### A. BACKGROUND AND STUDY AREA

At the request of the Municipality of

Lerum, an acoustic consultant Ingemansson Technology AB performed a mapping of noise exposures from different sources road traffic, railway, and aircraft noise, along with certain stationary noise sources in Lerum in 2003. The calculations were made on a grid with a distance of 15 m between each calculation point. In the spring of 2004, a socio-acoustic study was performed to provide knowledge on the health effects of noise, as a basis for health-based actions against noise exposures (for details see main report Öhrström et al., 2005a). The study was designed to cover a wide range of sound levels, from $L_{\mathrm{Aeq,24h}}$ 45 dB to more than 70 dB from both sound sources, with a large enough number of participants in various sound exposure categories to allow for detailed analyses of the effects of road traffic noise, railway noise, and a combination of the two noise sources. Participation was restricted to those living in residential buildings exposed to sound levels from railway and road traffic exceeding $L_{\mathrm{Aeq,24h}}$ 45 dB at the most exposed side.

The municipality of Lerum is situated east of Gothenburg, Sweden. A major part of the population lives along two major traffic routes and is exposed to both noise from road traffic on highway E20 (about 20 000 vehicles/24 h) and noise from a major railway (about 200 trains/24 h). A minor part of the study population lived in the area between the railway and the highways. The study area is approximately 20 km by 6 km (see Fig. 1). The residential buildings consist of detached, terraced, and apartment houses.

## B. ASSESSMENT OF SOUND LEVELS

In the first phase of the study, a GIS-based method was used to determine the noise exposure adjacent to each residential building. Calculations of sound levels from road traffic (highway and all other roads) and railway noise at the most exposed side were provided for each residential building by an acoustic consultant using a validated model (Nordic Prediction Method, Jonasson et al., 1996), the calculation program, Sound Plan, and the GIS program Arc View. In some cases (very small roads) for which no data on traffic volume were available, the calculated sound levels were based on a volume of 300 vehicles/24 h. All calculation points were determined at 2 m above the ground as free field values. This implies that reflections from all other facades in the area were included in the calculation for each building, excluding reflections from the façade of that building itself. In some cases (large buildings or buildings oriented with the gable facing the road or the railway) close examinations or site visits were performed in order to ensure that sound

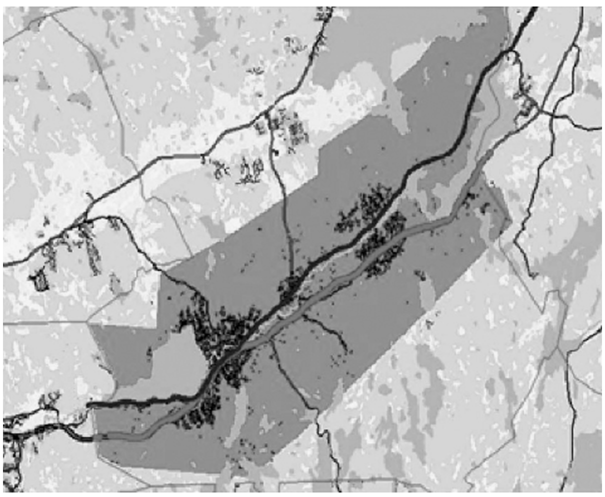


*Figure 1. The study area with the railway top and the high-way (bottom)*

levels were calculated accurately for different apartments in the building. For each type of noise source, sound levels were calculated as $L_{Aeq,24h}$ and $L_{Aeq}$ for day (0600-1800 hrs), evening (1800-2200 hrs), and night (2200-0600 hrs), and also as $L_{Amax}$ and $L_{den}$. In addition, the total sound exposure for road traffic and railway traffic was calculated as $L_{Aeq,24h}$ ($L_{Aeq,24h,tot}$) and $L_{den}$ ($L_{den,tot}$). The assessment of the total sound exposure did not consider whether the sound levels from road and railway were obtained at the same side of the dwelling or at different sides. However, only 12% of the study population lived in dwellings situated between the railway and the highway. The majority of these residents (194 out of 250 respondents) lived in detached houses (one-family villas surrounded by gardens) with very little shielding from railway and road traffic noise. The accuracy of the noise calculations was assessed at ±3 dB.

## C. STUDY POPULATION

After determining the sound levels for all residential buildings, we linked the data to the Land Registry to obtain noise exposure data for 7000 dwellings. Next, these data were linked to the local population register obtained from the Town Planning Office in Lerum municipality. Among this population, a selection was made of persons aged between 18 and 75 years who had resided at their present address for at least 6 months and who lived in dwellings with outdoor sound levels from separate sources ($L_{Aeq,24h}$ 45-50, 51-55, 56-60, and 61+ dB). The aim was to obtain at least 100 respondents within each exposure category; however, there were relatively few individuals in the highest noise categories, $L_{Aeq,24h}$ 61+ dB (see Table I). In all noise categories, except for 45-50 and 50-55 dB, all persons between 18 and 75 years of age were chosen. The 45-50 and 50-55 dB categories were twice as large as the categories with higher noise levels and therefore we selected only those who were born between the 1st and the 15th of each month.

In total, 2747 residents were selected for the study. Of these, 1953 responded to the postal questionnaire, giving a final response rate of 71%. The distribution of respondents among 16 combined road traffic and railway noise exposure categories in $L_{Aeq,24h}$ is shown in Table I, and the distribution of respondents among eight total noise exposure categories in $_{LAeq,24,}$tot is shown in Table II.

*Table I. Number of participants in the different road traffic and railway sound exposure categories.*

| | | Railway noise $L_{Aeq,24h}$ (dB) | | | | |
|---|---|---|---|---|---|---|
| | | **45-50 dB** | **51-55 dB** | **56-60 dB** | **61-72 dB** | **Total** |
| Road | 45-50 dB | 455 | 192 | 88 | 27 | 762 |
| Traffic | 51-55 dB | 294 | 158 | 89 | 49 | 590 |
| Noise | 56-60 dB | 134 | 126 | 108 | 66 | 434 |
| LAeq,24h | 61-70 dB | 42 | 31 | 46 | 48 | 167 |
| Total | N | 925 | 507 | 331 | 190 | 1953 |

*Table II. Number of participants in the different total sound exposure categories*

| | Total sound levels from railway and road traffic, $L_{Aeq,24h,tot}$ (dB) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | **48-50** | **51-53** | **54-56** | **57-59** | **60-62** | **63-65** | **66-68** | **69-72** | **Total** |
| Total | 142 | 526 | 403 | 377 | 260 | 146 | 66 | 33 | 1953 |

## D. EVALUATION OF ADVERSE EFFECTS OF NOISE

The questionnaire was designed to evaluate perceived symptoms and health effects of traffic noise e.g., annoyance, sleep disturbance, well being; it also included questions on psycho-physiological symptoms, hypertension, and antihypertensive drugs. The design of the questionnaire was based on previous research on the adverse health effects of noise e.g., Öhrström, 1989, 2004 and it included batteries of questions on: 1 the living environment, residency and various sources of nuisance; 2 annoyance and interference with various activities, both indoors and outdoors; 3 work situation, socio-demographic factors, and self-estimated noise sensitivity; 4 perceived sleep quality; and 5 general physical health and mental well being.

This article addresses only the results regarding annoyance. Annoyance caused by noise from: i road traffic; ii railway; and iii the total sound environment from road traffic, railway, and aircraft noise was evaluated with a five-point verbal category scale according to the ISO standardization of annoyance scales (ISO, 2003). The questions were phrased as follows: Thinking about the last 12 months or so, when you are here at home, how much does noise from (source) bother, disturb, or annoy you?" (Alternatives: "not at all," "slightly," "moderately," "very," and "extremely"). In the presentation of the results, the "annoyed" category consists of those who were moderately, very, or extremely annoyed by a given noise source, and the "highly annoyed" category of those who were very or extremely annoyed. Additionally, annoyance caused by the total sound environment.

The postal questionnaire was distributed together with an introductory letter in February-March 2004. Those who did not return the questionnaire were sent two reminders at 10-day intervals.

## E. STATISTICAL ANALYSIS AND TREATMENT OF DATA

The association between noise exposure and the degree of noise annoyance was analyzed using the Spearman rank order correlation coefficient ($r_s$). The possible differences between proportions (e.g., proportion annoyed were) tested using $X^2$ tests. The McNemar test (for paired analysis) was used to analyze the level of annoyance by different sources of noise in a given individual. In the multivariate analyses of the relative risk, where several noise sources were considered as well as background covariates, logistic regression analysis (with a dichotomous response variable) was used. The annoyance due to a single source (road traffic noise and railway noise, respectively) was studied and a possible inter-action between noise from railway and noise from road traffic was investigated. In the investigation of annoyance by road traffic noise, an interaction between railway noise and road traffic noise (on annoyance) is different, depending on the railway noise level. The same analysis was made for annoyance to railway noise. Another analysis was made (also using logistic regression), regarding the annoyance by the total traffic sound environment. We investigated whether the same total sound exposure was perceived as more annoying when caused by two equally noisy sources railway and road traffic compared with one dominating source either railway or road traffic. From the logistic regression models, the relative risk of being annoyed was estimated using the odds ratio and its 95% confidence interval. An ordinal logit model was used to estimate the dose-response relationship for different degrees of annoyance ("not at all," "slightly,... "extremely"). Linear regression and intraclass correlation were used to analyze the associations between annoyance due to single sources and annoyance due to the total traffic sound environment. Data were analyzed using SPSS for Windows, Version 12.0.1, and SAS, Version 9.1. Differences associated with p values below 0.05 were considered statistically significant.

## 3. RESULTS

### A. ANNOYANCE DUE TO SINGLE NOISE SOURCES

### *1. Annoyance due to road traffic and railway noise in relation to distance to the railway and the highway.*

All respondents lived at most 800 m from the railway track, and the majority 78% of them lived less than 800 m from the highway. Figure 2 illustrates the relationship between the distance to these main traffic noise sources and the prevalence of annoyance caused by each in isolation. Regarding railway noise upper figure, there was a fairly good correlation between distance from the railway track and the degree of annoyance five-point scale caused by railway noise ($r_s$) =-0.40, $p<0.001$, $n$=1942). No plausible explanation could be found for the somewhat higher prevalence of annoyance due to railway noise among residents living at a distance of 600-700 m from the railway track.

For road traffic noise lower figure, a somewhat weaker correlation was found between annoyance and distance to the highway ($r_s$ = 0.26; $p<0.001$; $n$=1942). Sound levels from highway traffic seemed to determine road traffic noise annoyance up to a distance of about 500 m from the highway, while for dwellings further away, the prevalence of annoyance due to road traffic noise was probably mainly determined by road traffic in local roads nearby. When the analysis was restricted to those living within 500 m of the highway, the correlation with road traffic noise annoyance was stronger ($r_s$ =-0.42; $p<0.001$; n=1109). The corresponding correlation between distance and railway noise annoyance for those living within 500 m of the railway track was ($r_s$ =-0.41 $p<0.001$; $n$=1684).

### *2. Annoyance due to road traffic and railway noise in relation to sound levels expressed in $L_{Aeq,24h}$*

Figure 3 shows the dose-response relationships for different degrees of railway noise annoyance (left) and road traffic noise annoyance (right), as a function of the sound level ($L_{\mathrm{Aeq,24h}}$). For example, we estimate that at 55 dB of railway noise, 10% were extremely annoyed by railway noise, 13% were very annoyed, 20% were moderately annoyed, 34% were slightly annoyed, and 23% were not annoyed at all. For road traffic at 55 dB, we estimate that

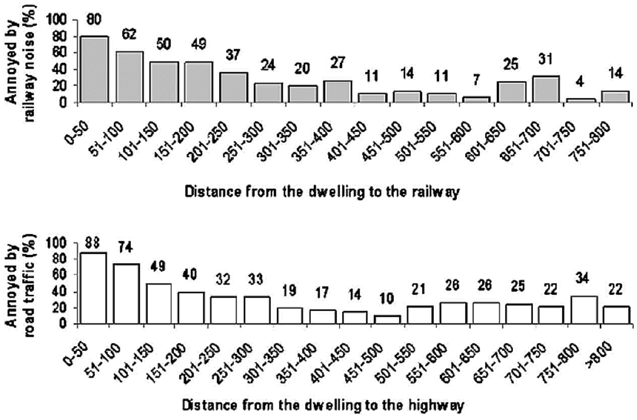



*Figure 2. Relationship between distance from the railway track and annoyance due to railway noise (top). Relationship between distance from highway and annoyance due to road traffic noise (bottom). "Annoyed" is defined as moderately + very + extremely.*

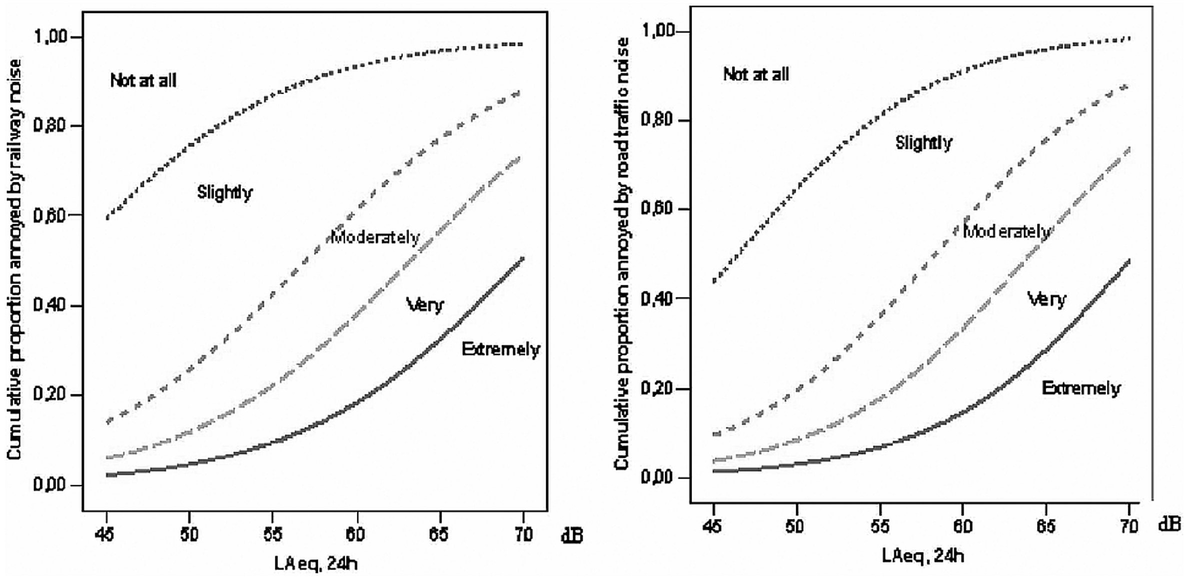



*Figure 3. Estimated dose-response relationships for the different degrees of noise annoyance, as functions of the sound level in LAeq,24h for railway noise (left) and road traffic noise (right). The area above the upper curve shows the proportion "not at all annoyed," the area between the curves shows the proportion "slightly," "moderately," or "very," annoyed, respectively, and the area below the lowest curve shows the proportion "extremely" annoyed.*

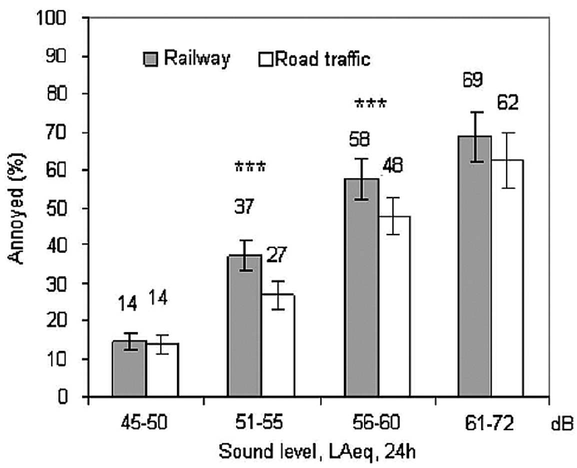



*Figure 4. Annoyance (% moderately, very, extremely annoyed, with 95% confidence intervals) due to road traffic and railway noise in relation to sound levels expressed in $L_{Aeq,24hr}$.*

6% were extremely annoyed, 11% were very annoyed, 19% were moderately annoyed, 45% were slightly annoyed, and 19% were not annoyed at all. For the grouped category of "annoyed" (extremely, very, or moderately annoyed), we estimate that at 55 dB, 43% were annoyed by railway noise and 36% by road traffic noise, while at 65 dB, 77% were annoyed by railway noise and 75% by road traffic noise.

The prevalence, with 95% confidence intervals, of annoyance caused by road traffic and railway noise, respectively, is presented in Fig. 4 for different sound exposure categories. Annoyance at the lowest sound levels (45-50 dB) was similar for the two noise sources, 14%. At higher sound levels(51-55 and 56-60 dB), annoyance due to railway noise was reported significantly more frequently than annoyance due to road traffic noise p0.001. No significant difference in annoyance between the two noise sources was found at sound levels above 60 dB.

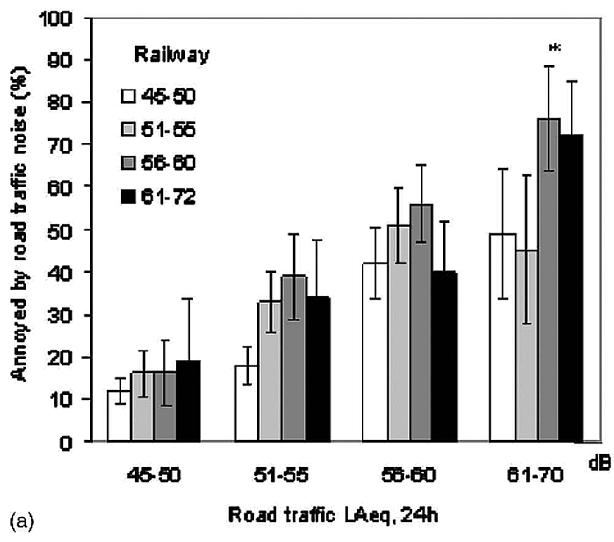
### B. ANNOYANCE AND POSSIBLE INTERACTION WITH EXPOSURE TO A SECOND NOISE SOURCE

In the logistic regression models, with annoyance from (road or railway noise) as the response variable, the explanatory variables were road traffic and railway noise (categorized as in Fig. 5) and interaction between road traffic noise and railway noise (operationalized by multiplying the road traffic noise variable by the railway noise variable), along with covariates (years spent in the dwelling, type of windows, bedroom window position, and noise sensitivity).

The analysis regarding annoyance due to road traffic noise showed a significant interaction effect for the highest road traffic exposure category ($p$=0.025). This means that the dwellings with very high road traffic noise exposure (61-70 dB) and, simultaneously, a high railway noise exposure (56-60 and 61-72 dB) show an amplified annoyance from road traffic noise. This amplified annoyance cannot be found for dwellings exposed to lower road traffic noise, e.g., the combination of noise 56-70 dB. The results are indicated from the descriptive values in Fig. 5 (left panel).

A similar response pattern was seen for annoyance due to *railway* noise. For the two highest railway noise categories (56-60 and 61-72 dB), the prevalence of annoyance due to railway noise was amplified by high exposure to road traffic noise, with significant interaction effects in both the 56-60 dB ($p$=0.036) and the 61-72 dB ($p$=0.005) categories of railway noise. For dwellings in the (56-60 dB) category of railway noise, annoyance due to railway nose was amplified by simultaneous exposure to high (56-60 dB) levels of road traffic noise; while in the 61-72 dB category of railway noise, annoyance due to railway noise was amplified by simultaneous exposure to very high (61-70 dB) levels of road traffic noise. The effect of high road traffic noise could not be found for the other railway noise categories (45-50 and 51-55 dB). These results are illustrated in Fig. 5 (right panel).

Similar analyses were performed using the category of "highly annoyed", defined as "very or extremely annoyed," as the response variable. For high annoyance from road traffic noise, no interaction could be found. However, in the 56-60 and 61-72 dB categories of



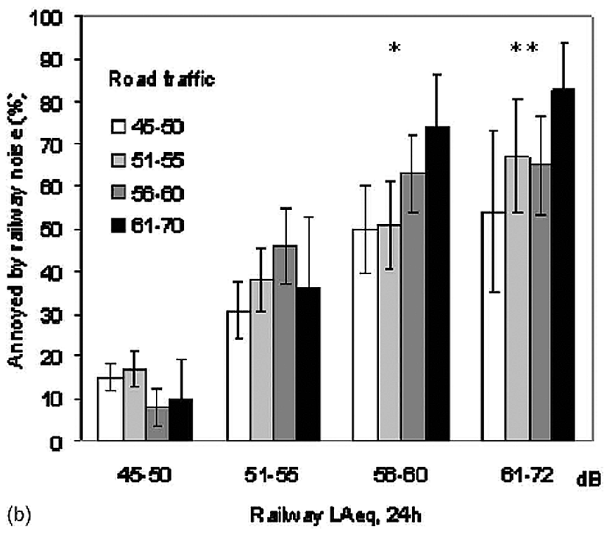




*Figure 5. Annoyance (% moderately, very, extremely annoyed, with 95% confidence intervals) due to road traffic noise in relation to sound levels from road traffic for each of the four different railway noise exposure categories (N=1,953) (right); annoyance (% moderately, very, extremely annoyed) due to railway noise in relation to sound levels from railway traffic for each of the four different road traffic noise exposure categories (N=1953) (left).*

railway noise, the annoyance due to railway noise was more prevalent if there was simultaneous exposure to high (56-60 dB) or very high (61-70 dB) road traffic noise ($p<0.0005$ and 0.013, respectively).

## C. ANNOYANCE DUE TO SINGLE NOISE SOURCES AND TO THE TOTAL TRAFFIC SOUND ENVIRONMENT IN RELATION TO TOTAL SOUND EXPOSURE FROM RAILWAY AND ROAD TRAFFIC ($L_{AEQ,24H,TOT}$)

The association between sound levels from road traffic and the degree of annoyance five-point scale due to road traffic noise was similar ($r_s=0.40$) to the association between sound levels from the railway and annoyance due to railway noise ($r_s=0.43$). The association between the total traffic sound exposure $L_{Aeq,24h}$,tot and annoyance due to the total traffic sound environment was of about the same magnitude ($r_s=0.37$) as that for the single noise sources.

We also analyzed the association between annoyance due to the single sources (road traffic and railway) to the total traffic sound environment (total annoyance). Three possibilities were compared, namely the *sum* (the total annoyance is the sum of the annoyance due to each single source), the *average* (the total annoyance is the average of the annoyance due to each single source), and the *maximum* (the total annoyance is the maximum of the annoyance due to each single source). Linear regression and intraclass correlation were used to investigate the association between each measure and the assessed total annoyance. The results showed that the *average* had the strongest association with the total annoyance: the linear regression showed an intercept of 0.25 and a slope of 0.91, and the intraclass correlation was 0.88 (where 1.00 is maximum). Thus, when assessing annoyance due to the total traffic sound environment, respondents are likely to have used an appropriate average of the annoyance due to the single sources, rather than the maximum or the sum.

For a more detailed analysis of the annoyance due to single sources and the total annoyance, the study material was divided into eight exposure categories, each 3 dB wide, ranging from $L_{Aeq,24h,tot}$ 40-50 dB up to $L_{Aeq,24h,tot}$ 69-72 dB. Figure 6 illustrates the observed prevalence of annoyance due to road traffic noise, railway noise, and the total traffic sound environment in relation to the total sound exposure expressed as $L_{Aeq,24h,tot}$.

The proportions annoyed by single noise sources road traffic or railway and by the total traffic sound environment were very similar in the five lowest exposure categories, although for total sound levels between 54 and 56 dB, the prevalence of annoyance due to railway noise was significantly higher than annoyance due to road traffic noise (26% versus 20%, $p=0.006$) and to the total

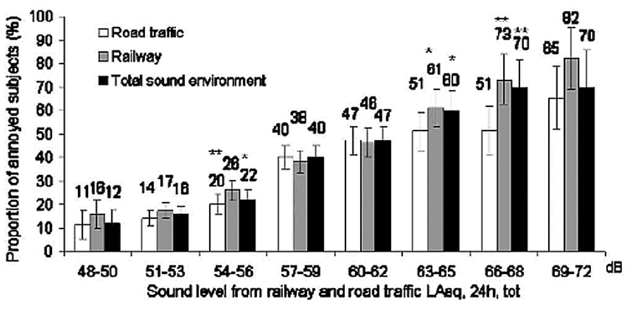



*Figure 6. prevalence of annoyance (% moderately, very, extremely annoyed, with 95% confidence intervals) from road traffic noise, railway noise, and the total traffic sound environment in relation to the total sound exposure from railway and road traffic, $L_{Aeq,24h,tot}$, N=1953.*

traffic sound environment (26% versus 22%, $p$=0.049), McNemar's test.

There were larger differences between annoyance due to the single noise sources and annoyance due to the total traffic sound environment in the three highest sound exposure categories. When the total sound level was between 63 and 68 dB, the prevalence of annoyance due to road traffic noise was lower than both the prevalence of annoyance due t railway noise (McNemar: $p$=0.041 at 63-65 dB, $p$=0.007 at 66-68 dB) and the prevalence of annoyance due to the total traffic environment (McNemar: $p$=0.029 at 63-65 dB, $p$=0.004 at 66-68 dB). However, there was no significant difference between total noise annoyance and railway noise annoyance at these sound levels. Additionally, the low number of observations in the highest exposure category (69-72 dB) meant that no significant differences could be shown in this category (see Tables II and III).

## D. MAXIMUM SOUND LEVELS AND NOISE ANNOYANCE

Further analyses were performed in order to determine why there were relatively large differences in annoyance due to road traffic railway traffic and the total traffic sound environment in the three highest combined sound exposure categories but not in the lower exposure categories. The sound level in $L_{Aeq,24h}$ for road traffic and for railway noise was similar in the different total sound exposure categories ($L_{Aeq,24h,tot}$). There were, however, large differences in L Amax levels (see Table III) between road traffic and railway noise.

The $L_{Amax}$ level in the different sound exposure categories varied between 65 and 86 dB for railway traffic and between 74 and 80 dB for road traffic. In the five lowest sound exposure categories, the median $L_{Amax}$ levels for railway noise were between 2 and 13 dB *lower* that those for road traffic noise. For the sound exposure categories of 63-65 dB and higher, there was a shift in the relative $L_{Amax}$ levels leading to higher levels for railway noise than for road traffic noise. In these sound exposure categories, where railway noise caused more annoyance than road traffic noise, the median values for $L_{Amax}$ for railway noise were 3-7 dB higher than the LAmax levels for road traffic noise.

## E. ANNOYANCE DUE TO THE TOTAL TRAFFIC SOUND ENVIRONMENT IN RELATION TO TOTAL SOUND EXPOSURE FOR SITUATIONS WITH AND WITHOUT DOMINANT NOISE SOURCES

In order to compare those who were exposed to two noise sources of the same magnitude and those who were exposed to one dominant source of noise, but to the same total traffic sound exposure level, a multiple logistic regression analysis was performed, with the *total traffic sound exposure* ($L_{Aeq,24h,tot}$) as one explanatory variable (continuous variable, no categorization) and total annoyance as the response variable ("annoyed"/"not annoyed"). To capture the situation in which railway and road

*Table III. Median sound levels in LAmax for railway and road traffic in the different total sound exposure categories for LAeq,24h,tot.*

| | **Total sound levels from railway and road traffic, $L_{Aeq,24h,tot}$ (dB)** | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | **48-50** | **51-53** | **54-56** | **57-59** | **60-62** | **63-65** | **66-68** | **69-72** |
| Number of respondents | 142 | 526 | 403 | 377 | 260 | 146 | 66 | 33 |
| Railway $L_{Amax}$ | 65 | 66 | 69 | 73 | 75 | 81 | 86 | 86 |
| Road traffic $L_{Amax}$ | 74 | 79 | 78 | 78 | 77 | 78 | 79 | 80 |
| Median difference in $L_{Amax}$ railway – road traffic -9 | -13 | -9 | -5 | -2 | 3 | 7 | 6 | |

*Table IV. Results from logistic regression model with response variable "annoyed by total traffic sound environment" and explanatory variables "total traffic sound exposure," type of dwelling "equal noise," or "one dominant source" and the interaction between sound exposure and type of dwelling*

| Response variable annoyed by total traffic sound environment | | | | |
|---|---|---|---|---|
| | **Estimate (B)** | **S.E** | ***p*** | **Exp (B)** |
| Total sound exposure ($L_{Aeq,24h,tot}$) | 0.149 | 0.014 | <0.0005 | 1.160 |
| Type of dwelling | -4.180 | 1.474 | 0.005 | 0.015 |
| Sound exposure *type of dwelling | 0.076 | 0.026 | 0.003 | 1.079 |
| Constant | -9.261 | 0.798 | <0.0005 | <0.0005 |

Type of dwelling = 1 if equal noise from railway and road traffic, 0 otherwise

traffic produced equal noise, the difference between railway noise and road traffic noise was calculated, and dwellings were classified into three categories: "road traffic dominant" (road-rail difference > 2 dB), "rail and road equally noisy" (rail-road difference between -2 and 2 dB), and "railway dominant" (railroad difference >2 dB). An interaction term between type of dwelling and noise exposure was added to the model (operationalized by multiplying the "type of dominance" variable by the "total traffic sound exposure" variable). The logistic regression analysis was based on the whole sample (rail and road equally noisy n=683, road traffic dominant $n$=752, and railway dominant $n$=518). This analysis showed no significant differences in total annoyance between "road traffic dominant" and "railway dominant" dwellings. Therefore the "road traffic dominant" and "railway dominant" dwellings were combined into one category; "one dominant source" dwellings ($n$=1270). The result from the logistic regression is shown in Table IV and also graphically in Fig. 7.

Figure 7 shows the results from the logistic regression models regarding the relationship between *total annoyance* and total traffic sound exposure for the two types of dwellings; "rail and road equally noisy" $n$=683 and "one dominant source of noise" $n$=1270, respectively.

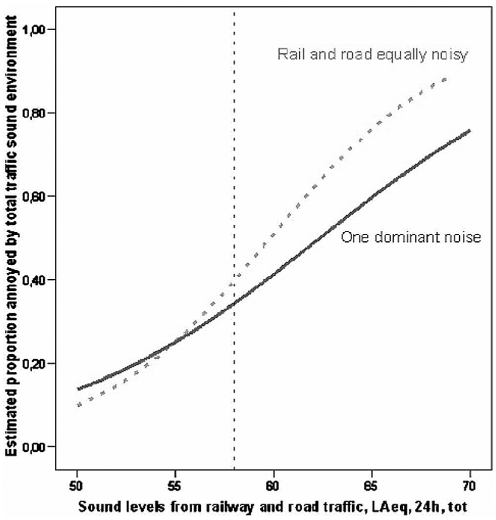



*Figure 7. (Color online) Estimated relationship between total annoyance (% moderately, very, and extremely annoyed) due to the total traffic sound environment and the total traffic sound exposure level ($L_{Aeq,24h,tot}$) for persons equally exposed to railway and road traffic noise upper curve and for those exposed to one dominant noise source, whether railway or road traffic (lower curve)*

The curves in Fig. 7 are estimated using the result in Table IV. The equation for the upper curve (exposed to equal noise from railway and road traffic noise) is: Probability of being annoyed $=\exp(-13.44+0.22x)/(1+\exp(-13.44+0.22x))$, where $x=L_{\mathrm{Aeq,24h,tot}}$ in both cases).

Figure 7 shows that for a low total traffic sound exposure there was no difference in total annoyance between dwellings exposed to one dominant source of noise (lower curve) and those exposed to equal noise from railway and road traffic upper curve. But as the total traffic sound exposure increased, the prevalence of total annoyance gradually became higher for dwellings where railway and road traffic contributed equally. Thus, there was an interaction between total traffic sound exposure and type of dwelling and this interaction was statistically significant ($p=0.003$). The difference in total annoyance between the two types of dwellings was statistically significant when total traffic sound exposure ($L_{\mathrm{Aeq,24h,tot}}$) was above 58 dB. We estimated that the expected difference in the proportion of total annoyance between a situation with one dominant noise source and a situation with two equally noisy sources was 0.2% at 55 dB, 10% at 60 dB (40% versus 50% annoyed), 17% at 65 dB (60% versus 77% annoyed), and 15% at 70 dB (75% versus 90% annoyed).

The same conclusion (a significant interaction with a higher proportion of annoyed with two equally noisy sources) was reached when a logistic regression was performed using another definition of annoyance due to the total traffic sound environment, namely "highly annoyed," defined as "very or extremely annoyed."

In the logistic regression model above, dwellings were categorized as being exposed to two equally noisy sources if the difference between the source was 2 dB or smaller, and as being dominated by one source if the difference was 3 dB or larger. We also performed another analysis, based on a subsample ($n=1662$), where we defined the sources as being equally noisy if the difference was 1 dB or smaller, and as having one source dominant if the difference was 3 dB or larger. The conclusions from this analysis were the same as above: the total sound exposure from two equally noisy sources caused a higher prevalence of total annoyance at high total sound levels than the same total sound exposure in situations with one dominant source (either railway or road traffic). The difference in total annoyance was again significant for sound levels above $L_{\mathrm{Aeq,24h,tot}}$ 58 dB.

## 4. DISCUSSION

### A. Annoyance from single sources- railway and road traffic

Annoyance due to road traffic noise varied from 14% at sound levels of 45-50 dB up to 62% at sound levels between $L_{\mathrm{Aeq,24h}}$ 61 and 70 dB. For the lower sound levels, this is in accordance with results obtained in meta-analyses based on large data sets (Miedema and Oudshoorn, 2001), and recent results from Swedish studies which show that 3% of participants were annoyed by road traffic noise at sound levels around $L_{\mathrm{Aeq,24h}}$ 42-43 dB (Öhrström et al., 2006). However, at higher sound levels, the prevalence of annoyance due to road traffic noise was considerably higher than would be expected from the dose-response relationships obtained by Miedema and Oudshoorn (2001) and by Öhrström et al. (2006); for example, 48% at 56-60 dB and 62% at 61-70 dB. To some extent, the high prevalence of annoyance due to road traffic noise in the present study might be explained by the simultaneous exposure to railway noise.

An overwhelming majority of studies have shown that railway noise causes less annoyance than road traffic and aircraft noise (e.g., Miedema and

Vos, 1998; Miedema and Oudshoorn, 2001; and review by Öhrström and Skånberg, 2006) while only a few studies show no support for a railway bonus (e.g., Kaku and Yamada, 1996; Yano et al., 1998). However, participants in the present study were more likely to be annoyed by railway noise than by road traffic noise being 7-10% higher than the corresponding percentage annoyed by road traffic noise. We have considered a number of possible explanations for this unexpected finding. It has been shown that railway noise is perceived as being more annoying in areas where there is simultaneous exposure to vibration from railway traffic (Öhrström and Skånberg, 1996; Ota et al., 2006). In parts of the present study area, the ground consists of clay, and so the passage of trains creates vibrations which propagate through the buildings. This may have made some contribution to the relatively high annoyance due to railway noise, but spontaneous reports of annoyance due to vibrations from the trains were rare, and other explanations seem more plausible.

Changes in railway traffic have taken place over the last 5 years with the number of passenger trains increasing by 6%, and also more and heavily loaded freight trains in night-time (4/night). In addition to this, there are plans to build additional railway tracks passing through the study area. When our survey was conducted, there were no concrete proposals concerning the localization of these new tracks, but nevertheless people may have been worried about the extension and feared increased disturbances from railway noise. Thus, while Lambert et al. (1998) found evidence for a "railway bonus" of up to 5 dB for existing railway lines at higher sound levels (around 70 dB), when comparing data from French socio-acoustic surveys, annoyance regarding new railways (or roads) was considerably higher than annoyance regarding existing infrastructures. The plans for additional railway lines may have outweighed the expected 5 dB railway bonus found in studies of stationary exposure situations. In a review of studies on community response to changes in railway noise, Huybregts (2003) concluded that there is an exaggerated annoyance response to noise when railway noise exposure changes. In one of the longitudinal studies reviewed by Huybregts (van Dongen and van den Berg, 1983), annoyance due to noise from a new railway line in Zoetermeer, The Netherlands, was evaluated 4 and 18 months after its opening. The prevalence of high annoyance was much greater 4 months after the opening than 18 months after, especially at levels below level day night (DNL) 55 dB. At these levels, annoyance after 18 months was as expected from the steady-state dose-response curve for railway noise (Miedema and Vos 1998). At sound levels above DNL 55 dB, annoyance also decreased after 18 months, but only by 3-4% as compared with annoyance 4 months after the opening of the new railway. Increased annoyance when the new infrastructure was planned was also demonstrated by Öhrström and Skanberg (1996). In this study, a much higher prevalence of annoyance due to railway noise was found in one of the study areas compared to other study areas with similar noise levels. In this area, new railway tracks were planned for local passenger trains. In a later study performed in the same study area a few years later (Öhrström, 1997) after the railway tracks had been rebuilt and an additional 90 local passenger trains introduced, the prevalence of annoyance due to railway noise decreased from 37% to 23% as an average for the entire study area, similar to that in other study areas with stationary exposure situations. In summary, we believe that concern about possible changes in railway noise may have increased the annoyance reported in the present study.

## B. ANNOYANCE DUE TO SINGLE NOISE SOURCES VERSUS TOTAL ANNOYANCE DUE TO COMBINED SOURCES

Risk assessment of the health effects of noise are often based on known dose-response relationships for single noise sources. The most recent comprehensive meta-analysis presents synthesis curves for the relationships between exposures from separate transportation noise sources (road, railway, and aircraft) and the percentage of individuals who were highly annoyed by these exposures (Miedema and Vos 1998; Miedema and Oudshoorn 2001). As research on the effects of combined noise sources is rare, corresponding relationships for noise from two or more simultaneously occurring sources are not yet available. Different theories exist on how to best assess the total sound exposure (Miedema, 2004; Nilsson, 2001); two of the models that have been suggested are the energy summation model, which was applied for assessment of sound exposure in this study, and the dominance model.

There is no standard method for assessment of annoyance due to the total sound environment, whereas validated questions are available (ISO, 2003) for noise annoyance due to single sources. In addition, the validity of a total annoyance judgment has been questioned by Miedema (2004). In a recent study (Ota et al. 2006), total noise annoyance was evaluated using a question on "Quietness of surroundings;" the response alternatives were "satisfied," "partially satisfied," "neutral," "partially dissatisfied," and "dissatisfied," and the percentage of "dissatisfied" responses was used as an index of total noise annoyance. Since the results by Ota et al. (2006) may be based on a range of noise sources, and not only traffic noise as in the present study, comparisons are not possible. In the present study, annoyance from combined noise sources was evaluated with a specific questions phrased to capture annoyance due to all types of noise from transport ("annoyance due to the total traffic sound environment"). The total annoyance was never higher than annoyance from the most annoying single noise source within the same exposure category (Fig. 6). Analyses indicate that the respondents assessed total annoyance as the average of their annoyance due to the single sources. This is in line with results from assessment of loudness in experimental studies (Nilsson, 2001). The results showed that the dose-response relationship between annoyance due to the total traffic sound environment (total annoyance) and the total sound level from railway and road traffic ($L_{\mathrm{Aeq,24h,tot}}$) was about the same ($r_s$=0.37) as the relationship between road traffic noise annoyance and sound levels for road traffic ($r_s$=0.40) and the relationship between railway noise annoyance and sound levels from the railway ($r_s$=0.43).

The results of this study imply that combined exposures to noise form road traffic and railway induce more extensive annoyance reactions than noise from single sources at the same sound level. This must be considered in risk assessments. When railway and road traffic were equally noisy ($L_{\mathrm{Aeq}}$ level), total annoyance was higher than when one of the two sources was dominant (rail or road) but the total sound level was the same. The difference in total annoyance between these two situations increased with higher sound levels (Fig. 7). A possible explanation is that the combination of road traffic and railway noise is a combination of a relatively high constant background noise (road traffic) and a more intermittent noise (railway). The difference in total annoyance between combined and single noise source situations was significant for total sound levels above 58 dB but not for lower sound levels. As shown in Table III, from about 63 dB ($L_{Aeq,24h,tot}$) the $L_{Amax}$ level from the railway was higher than the $L_{Amax}$ from road traffic. Such a combination of constant and intermittent noise with very high maximum sound levels may be more annoying than constant or intermittent noise alone, even if the total sound level is the same in the three cases. Railway noise, especially that from the heavy freight trains with high sound levels, was more dominant than road traffic noise at night, and it is well known that intermittent noise disturbs sleep more than continuous steady-state noise (Öhrström, 2000; Öhrström and Skanberg, 2004). The research questions should also be addressed for the combination of high road traffic noise and (intermittent aircraft noise).

### C. METHODOLOGICAL CONSIDERATIONS

As previous socio-acoustic surveys (e.g., Öhrström et al., 2006) have demonstrated that adverse effects of noise are rare at low sound levels, this study was restricted to residential areas with dwellings exposed to sound levels from road traffic and railway exceeding $L_{Aeq,24h}$ 45 dB. The assessment of sound levels at the dwellings was thorough, and the accuracy of calculated sound levels in $L_{Aeq,24h}$ was estimated at ±3 dB. Calculated LAmax levels for road traffic noise in areas further away from Highway E20 are more uncertain, since traffic counts were not available for small local roads, and so had to be estimated.

There are several aspects of this study which strengthen the internal validity, that is, how well the results reflect the true effects of noise in the population of the study area. First, subjects in the various sound exposure categories were selected randomly from the target population. Second, the response rate (71%) was higher than is usual in this type of study, minimizing the possible effect of a difference in the prevalence of annoyance reactions between respondents and nonrespondents. Third, the analyses were based on almost 2000 questionnaires, making the random error relatively small for annoyance and other common effects in the total sample. For example, the random error for the 29% of 1953 individuals who answered that they were (rather, very, or extremely) annoyed by road traffic noise was only ±2% (SE). For the analyses of subgroups, this uncertainty is larger. Among the 434 individuals in the 56-60 dB sound exposure category, 48% were annoyed by road traffic noise with a random error of ±5%. For the subgroup with only 167 individuals in the highest sound exposure category (62% annoyed), the random error was ±8% (Fig. 4).

## 5. CONCLUSIONS

Combined exposures to noise from two sources, road traffic and railway, induced more extensive annoyance reactions than noise from single sources at the same sound level. In situations where the total sound level was above 58 dB, the total annoyance was significantly higher for those exposed to two equally noisy sources (rail and road), compared to one dominant source. Therefore, effects of the total sound exposure should be considered in risk assessments and in noise mitigation activities.

The extent of railway noise annoyance was similar to that of road traffic noise annoyance at sound levels below 50 dB or above 60 dB. However, at sound levels between 51 and 60 dB, the proportion annoyed by railway noise was higher than that annoyed by noise from road traffic. These findings are in conflict with the majority of other European studies, which show that railway noise is less annoying than road traffic noise. Situational factors may have contributed to the extensive annoyance effects from railway noise, for example, changes and plans for new railway infrastructure. New comparative studies should be conducted to further evaluate annoyance due to road and railway noise and the relevance of a railway bonus in residential areas exposed to railway lines with a very large number of trains.

## ACKNOWLEDGMENTS

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## REFERENCES

Champelovier, P., Cremezi, C., Charlet, C., and Lambert, J. (2004). "Evaluation de la gêne due à l'exposition combinée aux bruits routier et ferroviaire!," ("Evaluation of annoyance due to combined exposure to noise from road and railway traffic!"). Lyon, France, INRETS, Report No. INRETS. 242.

Cremezi, C., Gautier, P. E., Lambert, J., and Champelovier, P. (2001). "Annoyance due to combined noise sources: advanced results," *Proceedings ICA International Commission for Acoustics: 17th ICA – International Congress on Acoustics*, Rome, Italy, edited by A. Alippi, September 2-7 (CD ROM).

EU Commission (2002). "A study of European priorities and strategies for railway noise abatement," *Final Report* No. 01.980, EU Commission, Directorate General for Energy and Transport, Belgium, ODS Reference No.: 00.2335.

Huybregts, C. (2003). "Community response to changes in railway noise exposure – a review," *Proceedings of the 8th Western Pacific Acoustics Conference (Wespac VIII)*, Melbourne, Australia, 7-9 April.

ISO (E). (2003). "Technical specification, acoustics. Assessment of noise annoyance by means of social and socio-acoustics surveys," SO/TS15666: (E).

Jonasson, H., and Nielsen, H. L. (1996). *Road traffic noise-Nordic prediction method*, Nordic Council of Ministers, Tema Nord, Copenhagen, Denmark, Vol. 525, ISBN 92 9120 836 1.

Joncour, S., Cailhau, d., Gautier, P. E., Champelovier, P., and Lambert, J. (2000). "Annoyance due to combined noise sources," *Proceedings of the 29th International Congress and Exhibition on Noise Control Engineering*, Nice, France, 27-30 August.

Kaku, J., and Yamada, I. (1996). "The possibility of a bonus for evaluating railway noise in Japan," *J. Sound Vib.* Vol.**193**, No.1, 445-450.

Kurra, S., Morimoto, M., and Maekawa, Z. I. (1999). "Transportation annoyance – A simulated-environment study for road, railway and aircraft noises, Part I: Overall annoyance," *J. Sound Vib*. Vol.**220**, No.2, 251-278.

Lambert, J., Champelovier, P., and Vernet, I. (1998). "Assessing the railway bonus: The need to examine the "new infrastructure" effect," *Proceedings of Inter Noise 1998*, 16-18 November, Christchurch, New Zealand.

Lercher, P., Brauchle, G., and Widmann, U. (1999). "The interaction of landscape and soundscape in the Alpine area of the Tyrol: an annoyance perspective," *Proceedings of Inter Noise 1999*. Fort Lauderdale, FL, 2-4 December.

Miedema, H. (2004. "Relationship between exposure to multiple noise sources and annoyance," *J. Acoust. Soc. Am.* Vol.**116**, No.2, 949-957.

Miedema, H. M. E., and Oudshoorn, C. G. M. (2001). "Annoyance from transportation noise: Relationships with exposure metrics DNL and DENL and their confidence intervals," *Environ. Health Perspect*. Vol.**109**, 409-416.

Miedema, H. M. E., and Vos, H. (1998). "Exposure-response relationships for transportation noise," *J. Acoust. Soc. Am.* Vol.**104**, 3432-3445.

Moehler, U., Liepert, M., Schuemer, R., and Griefahn, B. (2000). "Differences between railway and road traffic noise," *J. Sound Vib.*Vol.**231**, No.3, 853-864.

Morihara, T., Yano, T., and Sato, T. (2002). "Comparison of dose-response relationships between railway and road traffic noises in Kyushu and Hokkaido, Japan," *Proceedings of Inter Noise 2002*, Dearborn, MI, 19-20 August.

Nilsson, M. E. (2001). "Perception of traffic sounds in combination," Ph.D. Dissertation, Archives of the Center for Sensory Research, Stockholm University and Karolinska Institute, Stockholm, Sweden, ISBN 91-887- 8410-X.

Öhrström, E. (1989). "Sleep disturbance, psychosocial and medical symptoms – A pilot survey among persons exposed to high levels of road traffic noise," *J. Sound Vib.* Vol.**133**, 117-128.

Öhrström, E., and Skånberg, A.-B. (1996). "A field survey on effects of exposure to noise and vibrations from railway traffic. Part I; Annoyance and activity disturbance effects," J. Sound Vib. Vol.**193**, No.1, 39-47.

Öhrström, E. (1997). "Community reactions to railway traffic-Effects of countermeasures against noise and vibration," *Proceedings of Inter Noise 1997*, Budapest, Hungary, Vol.2, 1065-1070.

Öhrström, E. (2000). "Sleep disturbances caused by road traffic noise – Studies in laboratories and field," Noise & Health Vol.8, 71-78.

Öhrström, E., and Skånberg, A. (2004). "Sleep disturbances from road traffic and ventilation noise – Laboratory and field experiments," *J. Sound Vib.* Vol.**271**. 279-296.

Öhrström, E. 2004. "Longitudinal surveys on effects of changes in road traffic noise – Annoyance, activity disturbances and psycho-social well being," *J. Acoust. Soc. Am.* Vol.**115**, No.2, 719-729.

Öhrström, E., Barregård, L., Skånberg, A., Svensson, H., Ångerheim, P., Holmes, M., and Bonde, E. (2005a). "Undersökning av hälsoeffekter av buller från vägtrafik, tag och flyg i Lerums kommun," "Study of health effects from road traffic, railway and aircraft noise in Lerum municipality", Report No. ISSN 1400-5808, ISRN GUMMED-R-2005/1-SE, Department of Occupational and Environmental Medicine, The Sahlgrenska Academy at Göteborg University, Göteborg, Sweden.

Öhrström, E., Skånberg, A., Barregard, L., Svensson, H., and Angerheim, P. 2005b. "Effects of simultaneous exposure to noise from road- and railway traffic," *Proceedings of Inter Noise 2005*, Rio de Janeiro, 6-10 August, Paper no 1570 (CD ROM).

Öhrström, E., and Skånberg, A. (2006). "Litteraturstudie-Effekter avseende buller och vibrationer från tågoch vägtrafik." "Literature study – Effects of noise and vibrations from railway and road traffic," Report No. 112, ISSN 1650-4321, ISBN 91-7876-111-5, Occupational and Environmental Medicine, The Sahlgrenska Academy at Göteborg University, Göteborg, Sweden.

Öhrström, E., Skånberg, A., Svensson, H., and Gidlöf Gunnarsson, A. 2006. "Effects of road traffic noise and the benefit of access to quietness," *J, Sound Vib.* Vol.**295**, 40-59.

Ota, A., Yokoshima, S., Kamitani, K., and Tamura, T. (2006). "A study on evaluation methods of combined traffic noises, part 2: Community response to road traffic and conventional railway noises," *Proceedings of Inter-Noise*

*2006*, Honolulu, Hawaii, 3-6 December, Paper No.412 (CD ROM).

Ronnenbaum, T., Schulte-Fortkamp, B., and Weber, R. 91996). "Synergetic effects of nise from different sources: A literature study," *Procedings of Inter Noise 96*, Liverpool, U.K., edited by F. A. Hill and R. Lawrence July, Vol.5, 2241-2246.

National Institute for Communication Analysis (SIKA) (2000). "Utveckling av godstransporter 2010," ("Prognoses of freight transportation 2010"), Report No. 2000:7.

National Institute for Communication Analysis (SIKA) (2002). "utveckling av persontransporter, prognoser for 2010, 2020," ("Development of passenger transport, forecast for 2010, 2020"), Report No. 2002:1.

van Dongen, J. E. F., and van den Berg, R. (1983). "Gewenning aan het geluid van een nieuwe spoorlijn," (Adapting to noise from a new railway line), IMG-TNO Report No. RL-HR-03-02, Delft, The Netherlands.

Vos, J. (2004). "Annoyance caused by the sounds of magnetic levitation train," J. Acoust. Soc. Am. Vol.**115**, No.4, 1597-1608.

World Health Organization (WHO). (2000). "Guidelines for community noise" edited by B. Berglund, T. Lindvall, D. H. Schwela, and K.-T. Goh, Guideline Document, Geneva, Switzerland.

Yano, T., Murakami, Y., Kawai, K., and Sato, T. (1998). "Comparison of responses to road traffic and railway noises," *Proceedings Noise Effects '98 – 7th International Congress on Noise as a Public Health Problem*, Sydney, Australia, 22-26 November, Noise Effects '98 PTY Ltd.,

**GROWTH FOR AIR CARGO**

The Boeing Company projects that the global air cargo market will continue to exhibit strong, long term growth, according to the company's Current Market Outlook 2008. During the 20-year forecast period, Boeing projects that the industry will grow at an annualised average of 5.8 percent with the world freighter fleet increasing from 1,948 to 3,892 aeroplanes. This growth requires a total of 3,358 aeroplanes joining the freighter fleet by 2027, taking into account anticipated aeroplane retirements of 1,414 aeroplanes, according to the annual Outlook which was released prior to the 2008 Farnborough Air Show.

**NEW PLANNING RULES HAMSTRING COUNCILS**

New planning laws designed to speed up decision on big developments could stop councils acting on people's noise complaints, local authorities say. They say a new clause gives developers a "blanket exemption" from complaints about noise, smoke, odour and light. Ministers say people will be able to seek compensation under new laws, which they say do not "immunise" developers. Many MPs were concerned that allowing decisions to be taken by a new planning quango, that Infrastructure Planning Commission (IPC), would be undemocratic. But the bill completed its Commons stages and is now going through the House of Lords, where it will be examined line-by-line in October. However, Lacors, which oversees council's environmental protection work, has concerns about a new amendment which states criminal or civil proceedings cannot be brought for nuisance over works "authorised by an order granting development consent". It says it is "tying the hands of councils, leaving them unable to respond to the legitimate concerns of local people" and has written to Communities Secretary Hazel Blears to complain. It is backed by the charity Environmental Protection UK, which says the clause "would appear to remove access to any remedy for local health or environmental impacts caused by noise, dust, smoke, odour or light. " Policy officer Mary Stevens said: "This apparent blanket exemption is highly irresponsible."

### US AIR STATION, FUTENMA

A six-year court battle between 396 Futenma residents and Tokyo has ended with a Japanese court ordering the government to pay about $1.3 million for physical and mental damages from noise from Marine Corps Air Station Futenma. The residents filed the lawsuit in November 2002 claiming the national government was responsible for damages stemming from noise at the air station. They sought $2.5m million and demanded aircraft operations be suspended between 7 p.m. and 7 a.m. Chief Judge Yoshimitsu Kawai of the Okinawa Branch of Naha District court said there was sufficient evidence to show the residents were exposed to frequent damaging nose that caused mental suffering. He said the noise interfered with living normal lives especially affecting the quality of their sleep. He dismissed the residents demand to suspend night flight operations saying the Japanese government has no control over military operations at the air station. He also rejected the government's argument to exclude some residents from compensation because they moved to the neighbourhood while knowing there was a noise problem.

### TOYOTA HYBRID ROLLED OUT

Toyota has installed its new Active Noise Control Technology inside the Toyota Crown Hybrid, a half electric, half petrol car that uses speakers to cancel out noise from the engine, road, and other cars. Toyota says the whole system reduces noise levels inside the car by up to 8 dB, using three microphones inside the cabin that listen for noise, before passing it to a processor that flips it, and plays reversed signals back out of three speakers in the front doors and parcel shelf. The effect is a dampening of low frequency rumble, and a much quieter ride.

### FORD CUTS SQUEAK/RATTLE DEFECTS BY OVER HALF

Since 2004, Ford has reduced the number of squeak and rattle repairs prior to customer vehicle delivery by 57 percent.

### RACIST ORDINANCE?

The president of the Champaign County NAACP is concerned that a new noise ordinance adopted by the Rantoul Village Board may be used to target minorities. "The local minority leaders and other residents seem to believe such a measure may be targeting a particular race of people," said the Rev. Jerome C. Chambers, president of the Champaign National Association for the Advancement of Coloured People. Chambers said that minorities are concerned about how the ordinance will be enforced. Rantoul Police Chief Paul Farber said that race had nothing to do with the development of the noise ordinance. "This is a quality-of-life issue," Farber said. "People want Rantoul to move forward. We want this tool here to help." But Chambers suspects other motivations. "All of us know that the big issue in Champaign County has been one of racial profiling." He said. Farber said his officers do not engage in racial profiling and that playing loud car stereos is not limited to any particular race or ethnic group. The Rantoul Village Board has just passed an ordinance that authorises police to tow vehicles for a variety of offences, including playing loud music from a vehicle if the sound can be heard from 75 feet away or more.

## QUARRY DEVELOPMENT APPLICATION

The Windham Town Council (USA) will soon begin final deliberations on a quarry application from local developer Peter Busque. Busque has applied for a 55-acre quarry on 160 acres of land near Nash Road and Route 302. The Council will move point-by-point through Windham's mineral extraction ordinance. The application must meet each of the ordinance's 17 items, which deal with aspects of the quarry operation like noise and vibration levels, hours of operation, and safe exists. Much of the debate during the deliberation is likely to centre around each councillor's interpretation of the more vague aspects of the ordinance. While sound levels and quarry depth are measurable and defined in the ordinance, there is no set standard for vibration levels besides what is "discernible without the aid of instruments." The Planning Board, in approving the application, used the state standard for vibration levels. But the Town Council is not bound by that decision, and each councillor's vote on that issue may depend on their own idea of what is "discernible". The debate over noise levels will continue too. While Busque's noise study shows it meets the criteria in the ordinance, some of the residents have said that they were worried more about the constant nature of the quarry work than how loud it was. The constant bang of the rock hammer would always be in the background, and it would be an annoyance in their everyday life, they said.

## INDIANA TENT REVIVAL THREATENED

Crown Point (Indiana USA) city officials are threatening to revoke a permit for a church's tent revival meeting after numerous noise complaints from neighbours. Living Stones Fellowship was granted a permit to erect a tent on its property for a month long prayer festival that runs daily until midnight. Police Chief Pete Land says his department has issued 10 citations to the church between July 31 and Aug 10. One neighbour told a packed city council meeting that she has to turn on the air conditioning, the washer, dryer and fan to drown out the noise. Pastor Ron Johnson Jr. says the church will work with city officials. He says the noise comes from the cheering crowd, not from the music at the prayer festival.

## TUNABLE EXHAUST

Eberspacher GmbH and its Novi-based American subsidiary have developed technology that replaces a muffler with a speaker inserted into the exhaust system. That speaker emits sound waves that can either silence engine noise or tune it so that even a quiet hybrid sedan can roar. The promise of the device, which Eberspacher calls "ActiveSilence," is that a vehicle's exhaust note could be tuned to meet consumer preferences and safety requirements. "It allows you to completely calibrate the sound," said Martin Romzek, vice president for advanced engineering at Eberspacher. "We can cancel the bad sounds and enhance those that might be pleasing. The ability to customise engine noise could become increasingly popular as smaller engines and hybrids move only fuel conscious consumers to drivers who want performance or power in a gas friendly package. Others are working on similar technology, but aimed at adding noise to quieter vehicles. Lotus Engineering, a sister company to the British sports carmaker, recently introduced its "Safe & Sound" system for hybrid cars. That system places a loudspeaker in front of the radiator and projects the appropriate noise for the engine speed.