OUTDOOR NOISE PROPAGATION. INTEGRATION TERMS OF GENERAL EQUATION FOR SOUND PROPAGATION MODEL (SPM)

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Abstract

This work describes the adjunctive factors in general equation of SPM(propagation model due to vehicular traffic carried on by Ciolfi A.) . This model take his origins from theoretic and experimental considerations and was founded on sound propagation law in free field without obstacles between source and receiver. Experimental part regard the introduction of environmental parameters that complete the sound characterization. During this experimental part we carried on two Kind of measurements. One ore 24 hours for the territory and the other founded on short measurement (about 5-10 minutes and instantaneous). The short measurements was carried on the edge of the road. Moreover for each point was verified the entity and typology of vehicular flux.
SPM founds on existence of a dates bank relatively to emission levels. Through the transit conditions was possible to determine the acoustical effects combined to: inclination of the road, pavement of the road, flux velocity, type of vehicle internal noise of the vehicle (tyre, engine, etc). The model estimates the emission value to combine with adjunctives factors above mentioned through the emission of single vehicle for a reference period (observation time).
For each vehicle was taken the Single level event (SEL).

1. Experimental test and Sound Propagation Model (SPM)

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For each vehicle was taken the Single level event (SEL). The experimental remarks are composed of a large number of observations on a standar site (see ref. 8,9).Relatively to adjunctive factors,we have:

1) pavement of the road	from	- 0.3	to	+ 6.3	dBA
2) inclination of the road	from	0	to	+ 3.2	dBA

SPM take is analytical origin from the simple law for sound propagation in free field and omnidirectional with standard atmosphere and uniform temperature. In this condition we have that the Sound Intensity is

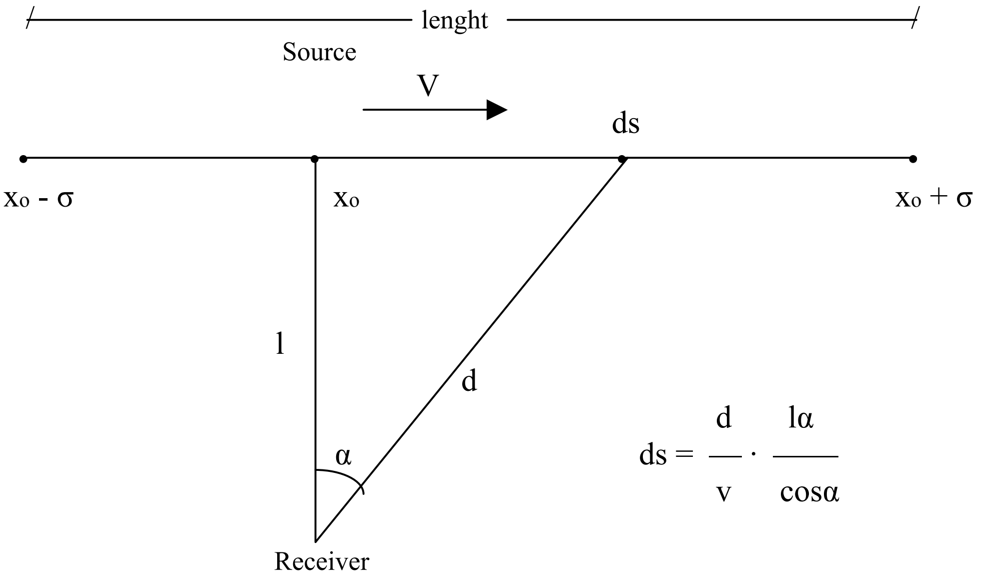
(1)

$$I = W/4\pi r^2 \Longrightarrow Li = Lw - 11 - 20 \log_{10}r \Longrightarrow$$

$$LI = Lw - 11 + DI - 20 \log_{10}r$$

$DI = 3$ (comparable to asphaltroad)

For our model we assume the case of a source the moves along a stretch of overall leght L as shown in figure



ds is a peak source with velocity V (m/sec) the irradiated energy will be

(2) $$dE = I\,dt$$

then replacing

(3) $$dE = \frac{W}{2\pi d^2} \cdot \frac{d}{V} \cdot \frac{d\alpha}{\cos\alpha}$$

The max value that α can assume is $x_o + \sigma$ the if we integrate proceeding equation between $x_o - \sigma$, $x_o + \sigma$ and having the knowledge that

(4) $$\mathrm{Cos}\alpha \; \frac{l}{d}$$

will be

(5) $$E = \frac{W}{2\pi} \int_{x_0 - \sigma}^{x_0 + \sigma} \frac{d^2}{Vld^2} \, d\alpha = \frac{W}{2\pi} \left[2\,(x_0 + \sigma) \right]$$

but because $x_0 + \sigma$ is arctg $\frac{L}{2l}$ will be

(6) $$E = \frac{W}{2\pi Vl} \left[2 \operatorname{arctg} \frac{L}{2l} \right]$$

Well knowing that the irradiated energy is connected to the sound velocity in air will be

(7) $$\left\{ C \; \frac{W}{2\pi Vl} \underbrace{\left[2 \operatorname{arctg} \frac{L}{2l} \right]}_{H} \right\} = dI \quad (a)$$

The relation in logaritmic form will be

(8) $$Leq = Lw - 10 \log_{10} l + 10 \log_{10} \frac{C}{V} + 10 \log_{10} H - 8$$

From this basis for knowledge that the mass and velocity are connected the tirth term in equation will be replaced with

(9) $$10 \log \int_{x_0 - \sigma}^{x_0 + \sigma} FS \; ds \longrightarrow 10 \log \int_{x_0 - \sigma}^{x_0 + \sigma} m \; \frac{dV}{dt} \; ds$$ will be

(10) $$\int_{x_0-\sigma}^{x_0+\sigma} mvdv$$

then our relation will be

(11) $$Leq = Lw - 11 + DI + 10 \log \left[\frac{m \times v'}{L \times ag} \right] + \Delta L - 20 \log H$$

In our relation there are the terms V' and ΔL.
V' is the relation between the sound velocity with car velocity.
ΔL are the sum of the conbined acoustical effect as reported in par. 1.Moreover we think to consider in ΔL the sound reflectivity of the road.In this case the phenomenon is regulated by reflection and refraction laws.In particular the direction of refracted ray is regulated by Snell law:

$\sin \varphi / \sin \varphi_t = c_1/c_2$ where

sin φ is the angle of the incident ray
sin φ_t is the angle of the refracted ray
c_1 and c_2 are the sound propagation velocity medium
The term "m" is the mass of the car in the case of a single car. If we consider more vehicles the term "m" will be integrate with the masses of the vehicles as following showen.

$$M = \frac{m_1p_1 + m_2p_2 + m_3p_3 + \ldots\ldots\ldots m_np_n}{m_1 + m_2 + m_3 + \ldots\ldots\ldots m_n}$$

Conclusion

The present model ofter good results because tested on experimental preliminary assumptions. The same consider the point source that movies on rectilinear motion and incremental thresholds due to power that movies on rectilinear motion and incremental thresholds due to power train velocity on road. In the second category we have the interaction tyre-road (sleep and stick) and aerodynamic sound.
All the observation has been compared to analytical model SPM. We have verified that the shifting is about 4-5 percent. This is due to environmental condition that will be object of further study.
Actually the model has been compared with other accreditated model as Burgess, Griffiths and Langdon, CSTB ecc…..and we have had a very low shifting (± 3%).
Futher work regard the revision and integration for such terms in equation so that to offer a general equation to predict the Sound Propagation in free for moving point source and according to UNI 9613 first and second part.

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