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Motocross Racing Track Noise Evaluation. New Linear Source Model Application

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ABSTRACT

This document contains some brief results of a research carried out in cooperation with the FMI (Italian Motorcycle Federation) over the last two years. The aim of this research was a complete analysis of noise propagation around a motocross field, with the double target of supporting local committees in their noise analyses in accordance with the Italian regulations, and also of guiding FMI technical committees on future noise limits in Italian competitions.

The first step of this work was a complete noise analysis of different motocross bikes (class, displacement, etc). Various noise test sessions were performed in 2006 and 2007 in different Italian cross racing tracks, with the aim of characterising bike noise power levels and noise directional properties. Furthermore, exhaust silencer noise levels and noise levels contributed by engine were measured.

Need to manage local cross racing track activities has induced our research to identify a mathematical algorithm able to describe a linear noise source of a cross racing track. It was possible to calibrate and validate this new algorithm by applying it to a noise mapping software in different test sections of training sessions and official competitions. This approach had never been used before and allows a complete evaluation of noise levels over a large territory around a cross racing track and it can be compared with local noise limit regulations.

1 INTRODUCTION

This work is a summary of a two year activity developed as consultant of the Italian Motorcycles Federation for motocross racing track noise emission analysis.

The progressive introduction of noise mapping on Italian local territory has determinated growing attention to noise impact from motocross activities. The Italian Motorcycle Federation, by means of its technical office, FEDERMOTO, has planned an intensive “on site” analysis of noise emission from bikes and racing tracks. This work, involves a panel consisting of federal technicians, two major Italian silencer producers and racing teams.

Beginning in April 2006, the research activities had the double target, the first being to investigate motorbike noise emission in different configuration, comparing these noise levels with present Italian sporting limits in official competitions. The second target was to analyze a possible correlation between single bike noise levels and noise impact on the territory surrounding the racing track. This second point identified a mathematical algorithm describing the racing track as a linear noise source, depending on a few coefficients

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correlated with specific motocross bike features. In the years 2006 and 2007, the mathematical method was calibrated and validated in different Italian motor tracks.

2 MOTOCROSS BIKE NOISE ANALYSIS

2.1 Static test sessions

In the spring of 2007, we performed an accurate noise investigation at the Monterosato motocross racing track, located in central Italy. During this test session, "static" noise emission of 20 cross bikes was investigated; noise measurement was performed in accordance with the Italian Motorcycle Federation sport regulations. For the year 2007 the static limit at the exhaust silencer was fixed at 94 dBA as pressure level weighed A.

The static noise test method is carried out by measuring the pressure level at 0.5 metre from the exhaust silencer with an angle of 45° as shown in Figure 1.

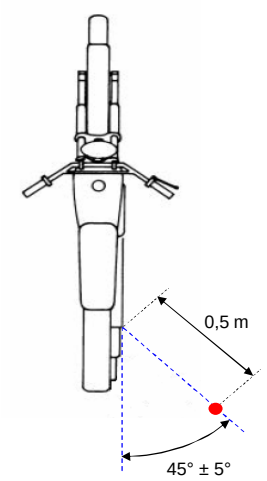

Figure 1: Static noise test method.

A second step of the noise evaluation was concentrated on noise propagation around a single bike, referred to the ISO 3744 procedure; we investigated the noise emission of four bikes at 1 and 5 m on each side. Depending on bike displacement, all the noise measurements were executed at the RPM fixed by the FMI cross regulations,.

An example of a data sheet related to a HONDA 250 is shown in Fig. 2.

The static noise analysis permitted the identification of two bike groups (A and B) with different average noise emissions, noise emission difference was more than 3 dB(A). The A group presented values exceeding the FMI regulations, whereas the B group was composed of bikes whose static noise emission respecting the limits, as indicated in Tab. 1. Details of the static level for each bike are shown in Fig. 3 and Fig. 4.

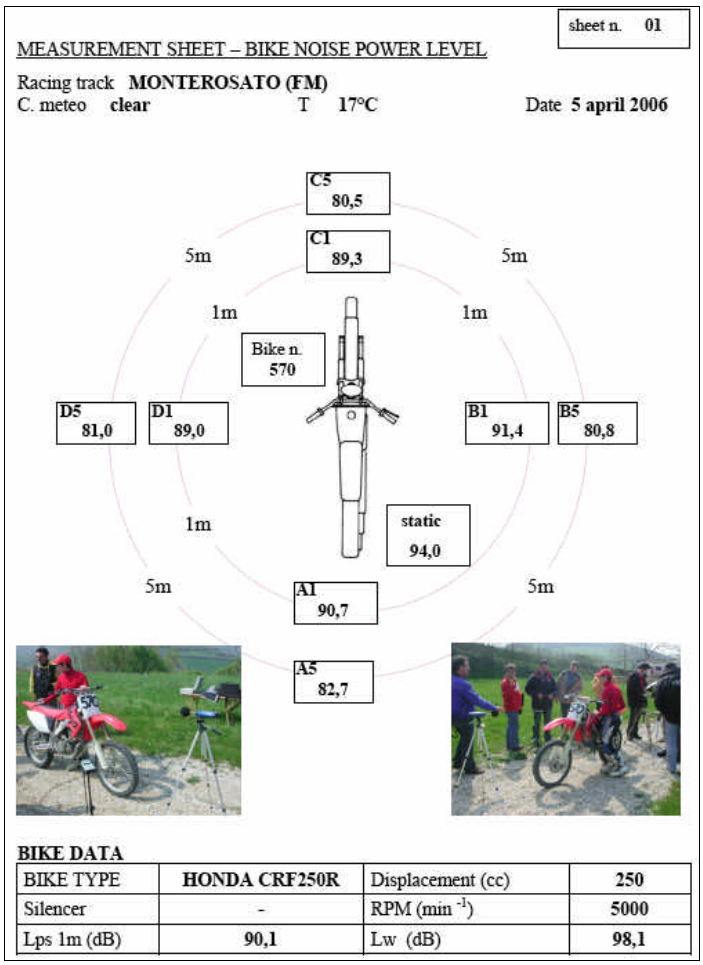

Figure 2: Noise propagation characterization.

Table 1: Average static noise levels.

Group A	→	Static noise > 97 dBA
Group B	→	Static noise ~ 95 dBA

During the noise test day, different analyses were performed, with the aim of collecting as much information as possible, regarding the influence of different factors on bike noise emissions, such as RPM, engine noise level compared with exhaust noise level, noise tap (db killer) presence, etc.

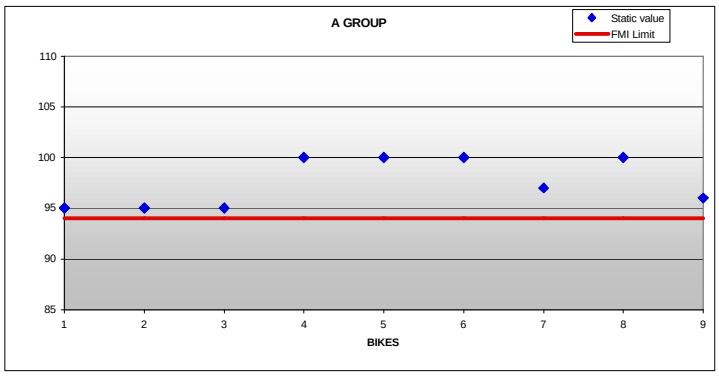

Figure 3: Static noise values Group A

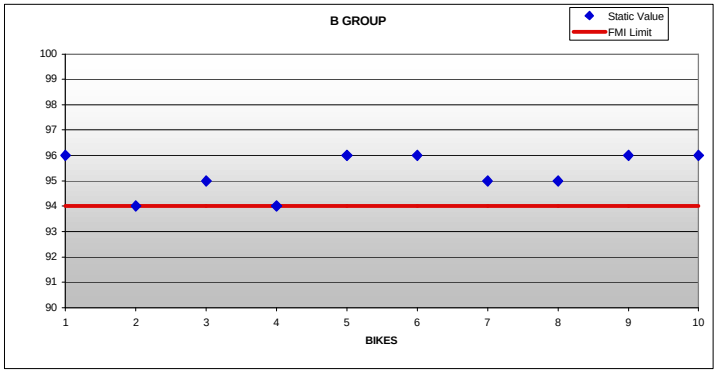

Figure 4: Static noise values Group B

Table 2 summarizes the sound power level in detail for the four bikes investigated; individual values were determinated on average sound pressure levels in accordance with the method described in Fig. 2.

Table 2: Sound power levels.

Bike	Sound power level LwA
1 – Honda 250	97,7
2 – KTM 450	104,1
3 – Honda 150	99,3
4 – Honda 450 (with silencer)	99,0

2.2 Racing track noise evaluation

Once the two cross bike groups described on par. 2.1 were prepared, it was possible to arrange two race sessions in the Monterosato track; competition time was 20 min for each sessions. During the two sessions, we arranged a set of instruments, to record noise levels at eight specific points located along the racing track, at limit of the Monterosato track property and close to a dwelling. The aim of this noise recording was to correlate the noise emission levels of the two groups with the noise impact on the surrounding territory. The distribution of measuring points along the racing track is shown in Fig.5.

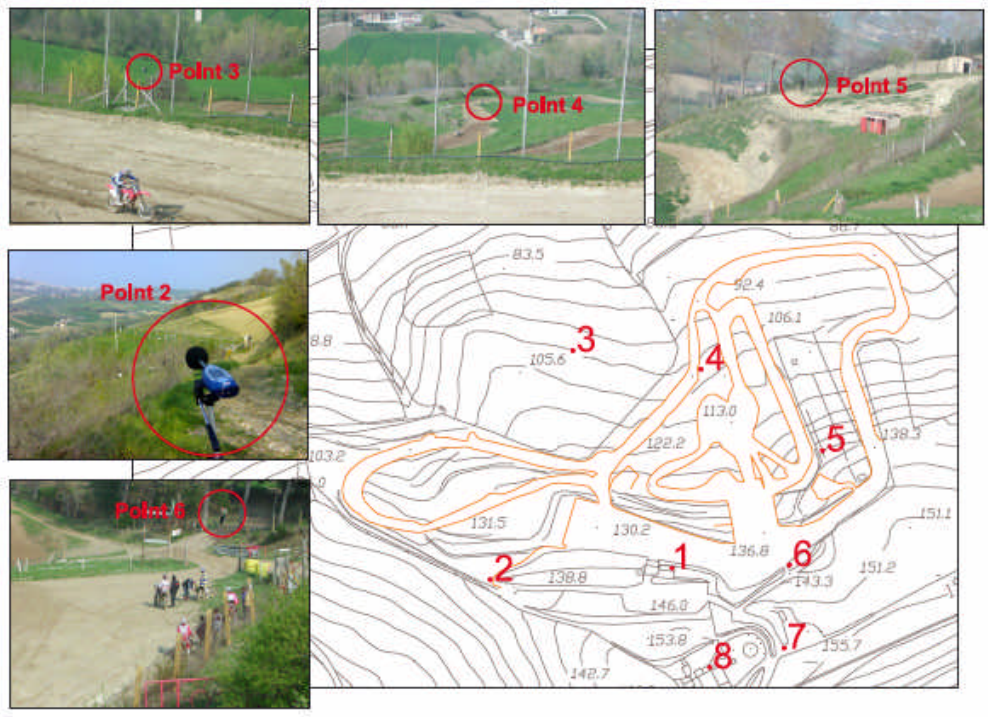

Figure 5: Noise measurement positions.

3 RACING TRACK NOISE MAPPING

3.1 Mathematical model

Motocross racing track noise evaluation was performed by means of a specific propagation software modelling on a Mithra platform; it allows to create a 3D model of the investigated territory including houses, screens, specific reflecting or absorbing areas and other ground elements having an influence on noise propagation.

Specific noise sources can be defined on the 3D model; the racing track was defined as linear source, as shown in Fig. 6. The software model was then completed with singular receptor, both on the ground and on the front of the receptor as well.

3.2 Noise source determination

The linear noise source, representing the racing track, was calculated by starting from the single bike noise power level (as per par. 2.1), and taking into account the number of bikes, displacement and other coefficients.

This analysis has determined a specific algorithm, describing the linear noise source as follows:

$$L_w = L_{wm} + 10\log(flow * v) - 10 \quad (1)$$

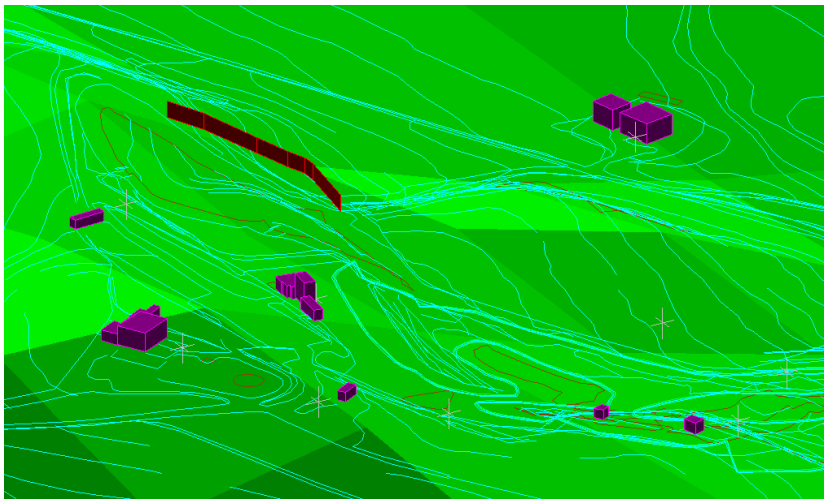

Figure 6: Racing track 3D model.

where:

L_w = sound power level A per linear metre;
v = average bike speed (km/h);
flow= average hourly bike flow (bike/h).
L_{wm} = average bike sound power level at 40 km/h, (dBA), defined as follows:

$$L_{wm} = 64 + 20\log(40) + C \qquad (2)$$

C coefficient is a function of bike displacement and can assume the following values:

C = 0 displacement < 125 c.c.
C = 2 displacement between 125 c.c. and 150 c.c.
C = 4 displacement between 150 c.c. and 250 c.c.
C = 8 displacement between 450 c.c. and 500 c.c.

Noise mapping was evaluated in the two different test conditions, corresponding to groups A and B, mentioned above. For each condition, the liner source power level A was calculated, through the aforementioned algorithm. Corresponding values at different frequencies are shown in Tab. 3; frequency distribution was based on detailed noise emission analysis described in Par. 2.1, referring to the four bikes in Tab. 2.

Table 3: Linear source power level.

Monterosato racing track										
Frequency (Hz)		**63**	**125**	**250**	**500**	**1 K**	**2K**	**4K**	**8K**	**Global LwA/m**
A group (high noise)	**Lw/m**	101,3	105,6	103,8	103,6	95,9	90	86,8	82,3	**103,4**
B group (low noise)	**Lw/m**	101,3	103,5	101,3	98,8	86,6	86	80,9	73,8	**98,7**

3.3 Model calibration

After noise propagation analysis at the different receptors, the values obtained were compared with the noise measurement described in par. 2.2. Italian regulations define local noise territory mapping, which is divided into six classes with different noise limits; racing track noise emissions are regulated by a specific law (D.P.R. 304/2001), that defines hourly limits around racing tracks.

For this reason, our propagation analysis and relative algorithm, were calibrated in reference to an hourly noise value, establishing in this way the worst noise emission condition around the racing track.

The effect of calibration work fixed the “C” coefficient and the “64” factor in formula 2).

Further propagation analysis, showed a good agreement between calculated and measured noise levels at the measuring points as per Fig.3; differences are limited to +/- 2 dBA.

3.4 Noise propagation analysis

Following model calibration, it was possible to generate noise propagation maps at 1.5 m high horizontal plan and vertical source-receptor maps; in Fig. 7 an example of horizontal noise propagation around the racing track is reported.

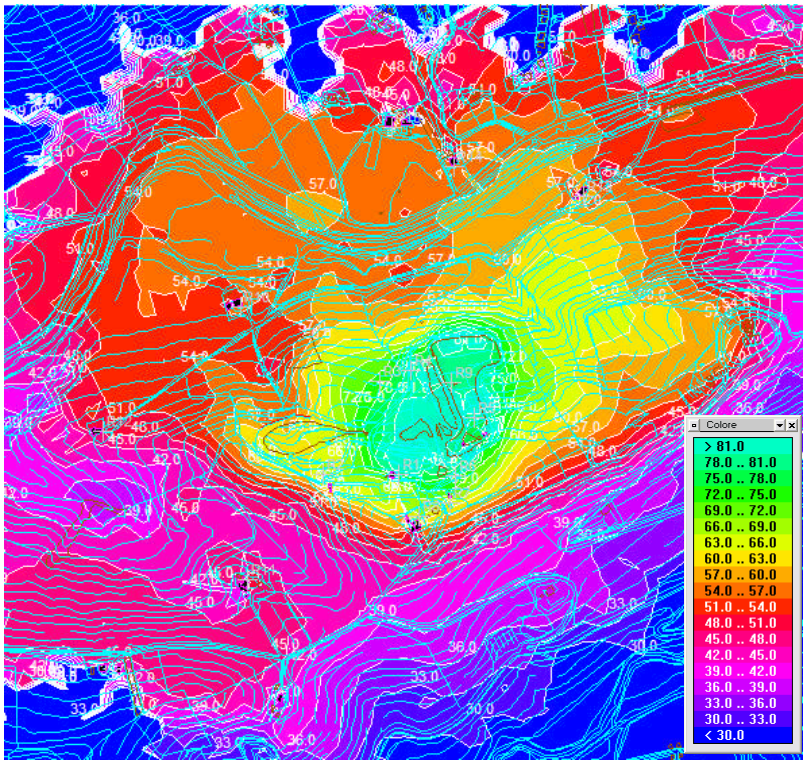

Figure 7: B group horizontal noise propagation.

By comparing the noise propagation areas, covered by the two bike groups, it was possible to evaluate noise impact on the territory due to the differences in the bike groups power level; results are shown in Fig. 8 in terms of areas at different noise levels.

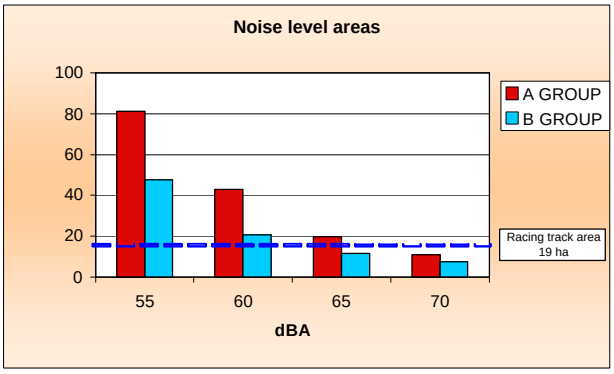

Figure 8: Noise level area extents.

By analyzing the different noise level extents, of the two bike groups, it was possible to calculate an increase, at 70 dBA, of 70% of the area covered at this noise level. This brought to light the importance of noise limit reduction even if limited to a few dBA.

3.5 Model validation

During the years 2007 and 2008, in cooperation with the Italian Motorcycle Federation we performed other noise measurement session in two racing tracks located in central Italy; the first one was at the Gioiella track during the Italian International Championship 2008. The second session was carried out at the San Venanzo racing track, during the interregional championship 2008, held on the first of May.

On these two different occasions, we measured noise levels at different receptors, modelling the racing track area, as described in previous paragraphs. Linear noise sources ware simply calculated by means of the algorithm described in par. 3.2.

Noise level differences, between calculated and measured values, limited to +/- 2 dBA, confirmed our algorithm's reliability.

4 COMPETION NOISE LIMITS

During different test sessions, we examined the static noise emissions of about 300 cross bikes in different race set up conditions; this quantity of noise data, has allowed us to summarize some important points, aimed at reducing noise limits.

4.1 Italian Motorcycle Federation limits

At the 2007 meeting, management of technical office Italian Motorcycling Federation examined the results of the first part of our work, with the aim to evaluate a possible noise emission reduction (as static values) during official Italian competition.

An analysis of our investigation, can be summarized in the following points:

- A difference of 3 dBA as average power level of a cross bikes group, determines an impact on the surrounding territory of approximately 3.5-4 dBA at the receptor investigated.
- Bike mechanical noise emission does not go down to 92 dBA; due to this evidence, reducing exhaust noise limits under this trig value does not seem to be useful.

Following these results, the FMI has taken several decisions:

- To continue noise investigation in the year 2008.

- To fix the static noise limits for the 2008/2009 Italian Championships, at 94 dBA, in order to conform to motocross and enduro regulations.
- To involve, in the research activity, major bikes producer factories, silencer producers and to compare the results with the International Motorcycle Federation technical committee.

4.2 International Motorcycle Federation limits

The International Motorcycle Federation's activities regarding motocross noise emission are aimed at define different noise test methods, instead of the static test method used at present.

Nowadays, the importance of noise analysis in motorcycle sport activities is well known; fixing new restrictive limits is possible only in cooperation with motorbike producers, silencer producers and racing track managers.

New possible noise test methods have been identified and evaluated; dynamic test method proposed by the FIM presents relevant problems on racing tracks, due to its technical complexity.

5 CONCLUSIONS

The new approach to motocross racing track noise impact assessment, permits a complete and exhaustive analysis of the "noise problem". By modelling the racing track territory it is possible to analyze absolute noise immission values by local receptors. The target of this predictive analysis is to design noise reduction solutions around a racing track, such as artificial screens, natural ground screens or racing track layout modifications.

Racing track predictive assessment, permits the verification of the accordance between an existing or new motocross track noise emission with local district noise regulations. The advantage of this new approach, that uses racing track noise mapping, consists in the possibility to avoid, or at least minimize, annoyance problems to the resident population in the surrounding area.

6 PROSPECT ANALYSIS

Motorcycle noise emission investigation allows many possible developments. The main aspects discussed during the Italian Motorcycle Federation meetings can be summarized as follows:

- To carry on, with further investigations on bike noise characterization, and in particular attention to study the static noise emissions vs. engine RPM. In the mean time, a deeper investigation is necessary on the different contributing to overall bike noise emission from the engine, exhaust and other elements.
- With reference to the linear noise source algorithm, further studies will be aimed at finding an accurate analysis of different coefficients in connection with bike parameters; further investigation will be carried out such on environmental factors, as wind influence, ground absorbing effect, noise source directionality, etc.

The good results from our motocross noise investigations, induced the FMI to export our analysis method to bike speed sector; with this aim, in the spring of 2008, a specific panel was set up in which, technicians, Italian speed racing managers (Monza, Mugello, Misano, Varano, Franciacorta, Vallelunga), major silencer producers (Arrows and Leovince-SITO Group) and major motor bike producers (Yamaha Italy, Kawasaki Italy, Honda Europe, Honda Italy, Ducati, Aprilia, Benelli, Beta/Bianchi, MV Augusta) are taking part.

The work panel started its activity last spring with two first noise measurement sessions, one at the Franciacorta racing track and the other at Misano.

7 REFERENCES

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