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NOISE CONTROL FOR A BETTER ENVIRONMENT

New approach to accredited noise monitoring systems according to ISO 20906

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ABSTRACT

Noise is one of the main challenges that airport managers face when reconciling their activities with the environment around them. The recording and monitoring of noise in the environment enable the awareness of the current situation of the municipalities close to the airport and its communication to the affected population.

EMS Brüel & Kjær, as a company that manages Noise Monitoring Systems of AENA airports, has obtained ENAC accreditation (National Accreditation Entity recognized in more than 90 countries) as a testing laboratory for continuous monitoring of environmental noise levels in Madrid and Barcelona airports according to ISO 20906 (Unattended monitoring of aircraft sound in the vicinity of airports). Both airports add up to more than 700.000 annual operations and more than 40 noise monitoring terminals.

ENAC accreditation in ISO 20906 represents a guarantee in relation to data quality provided by the system. Throughout this article the process of application of the regulation in these airports is summarized, as well as the evaluation of the results obtained, highlighting the procedures of data validation, location analysis, uncertainties calculation, quality assurance, as well as other social interest aspects.

Keywords: Noise, aircraft, environment, airport, accreditation
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1. INTRODUCTION

Aircraft noise is one of the main problems faced by large airport managers. While individual aircrafts have become less noisy due to technological improvements [1, 10], the growing amount of air traffic in Europe means that an important part of the population is still exposed to problematic noise levels. In the EU, aircraft noise is the third biggest source of noise exposure after road and rail traffic [13].

In fact, the European Environment Agency has estimated that more than 4.1 million people were exposed to L_{den} levels above 55 dB from aircraft at 85 major airports (over 50,000 movements per year) in 2011, which accounted for 3.2% of the total population exposed to this noise level from all sources covered by the EU Environmental Noise Directive [2, 3].

Aircraft noise is considered more annoying at the same noise exposure level than road or railway noise [9]. The tonality of the source noise, the spectral distribution, a negative attitude towards aircraft or the source position could be potential causes for this difference in reactions [12].

Aircraft noise is a significant environmental challenge and airports managers play a crucial role in facilitating coordination between all relevant stakeholders to identify the most suitable noise mitigation measures based on the specific local circumstances and resident's needs. Airports can also play an important role in the implementation of these measures. For example, by establishing or contributing to sound insulation houses, with noise monitoring systems, or forcing airlines to use better noise abatement procedures [4]. In addition to reducing aircraft noise, transparent and regular communication with residents has its own added value, enhancing trust and potentially reducing annoyance.

The main airport managers work on this direction, trying to improve the relations with the environment through transparent policies based on communication, trust and quality. That is the reason for that EMS Brüel & Kjær, company that provides technical assistance and maintenance service of Noise Monitoring and Flight Path Systems of AENA (Spanish airports manager), has accredited by ENAC (LE/2644) as testing laboratory (ISO/IEC 17025 [5]) for the uninterrupted monitoring of environmental noise levels within the airport environment according to ISO 20906 standard (Unattended monitoring of aircraft sound in the vicinity of airports) [7] in the A.S. Madrid-Barajas and Barcelona-El Prat airports.

Madrid and Barcelona airports are the first two airports in the world to provide accredited noise data according to ISO 20906 standard, specifically for noise monitoring in airports. These airports, the biggest in AENA, have 7 runways, more than 700.000 operations per year and they add up to more than 40 noise monitoring terminals.

This fact means a step further in the assurance of noise data quality that is offered publicly and, on this way, a confidence reinforcement to be obtained using procedures, tools and technical staff that follow the ISO 20906 standard for the technical criteria, and the ISO 17025 standard for the quality criteria, all endorsed by an accrediting entity (ENAC) recognized in more than 90 countries.

Throughout this article, the laboratory accreditation process according to the ISO 20906 standard is detailed, paying special attention to the application of the most relevant technical aspects, the data validation procedures, quality assurance tasks, and the difficulties found during the application of the standard.

The results obtained through the application of those procedures are also detailed and an evaluation of the process and results is done.

2. PURPOSE

The purposes of this article lie in the evaluation and analysis of the practical application of the ISO 20906 standard in the noise monitoring systems of two big airports. Likewise, to carry on a reflection about the added value that this accreditation is providing for the monitoring systems already consolidated and working for more than 10 years.

In addition, this article intends to analyze the difficulties of the technical application of a standard that is not very used and without updating since the year 2009. It pretends to analyze the way in which it is complemented with the current Spanish legislation of environmental noise and with the ISO 17025 standard, that adds management aspects and quality assurance.

3. METHODOLOGY

The methodology followed is that of an ENAC accreditation process, based on completing the following phases marked by the accreditation entity, ENAC, for testing laboratories according to ISO 17025 (Figure 1)

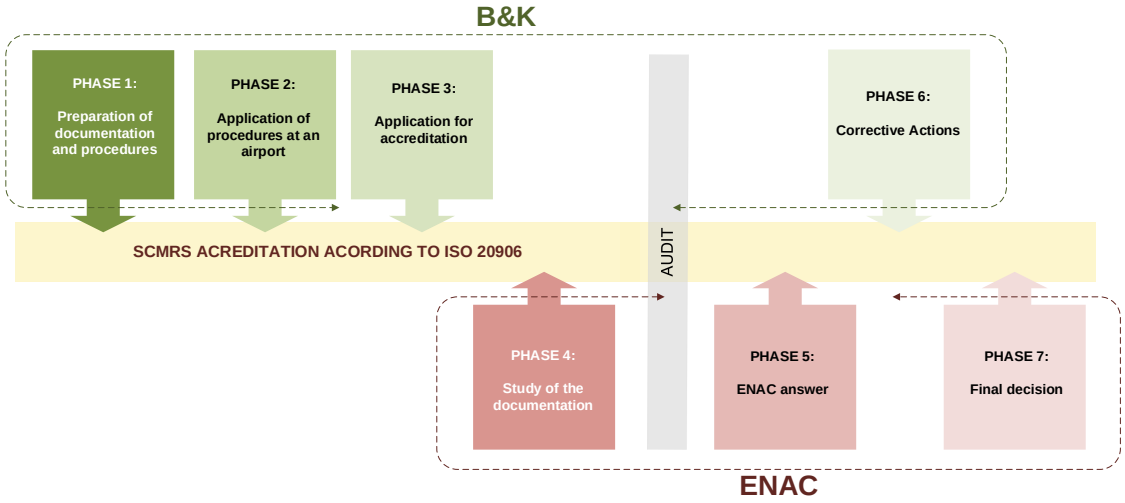


Figure 1: Accreditation phases

3.1 Elaborating technical documentation

The first phase in the accreditation procedure involves the elaboration of the laboratory technical documentation, focusing on collecting the technical procedures used in it to comply with ISO 20906, and the general or quality procedures that reflects the laboratory practices to ensure the quality, traceability and integrity of the data according to ISO 17025.

In these procedures are collected the technical characteristics of the measurement equipment, the measurement location requirements, the data grooming processes, report structure, uncertainties calculation etc.

3.2 ISO 20906 application

ISO 20906 standard focuses on the unattended noise monitoring system produced by aircraft in the airport environment. This standard specifies the requirements for conducting unattended aircraft noise measurements in long term, as well as the minimum requirements of the measurement equipment and the location chosen for the uninterrupted noise data measurement.

It also establishes the principles of detection, identification and classification of the aeronautical events, whether performed manually or by software, and the aspects to

consider in the data processing, such as weather conditions or background noise. Minimum correlation values between the detected aircraft events and the aeronautical operations are established on the influence range of each NMT.

Finally, it marks the minimum content that the aircraft noise reports should have (e.g., indicators, weather conditions, aeronautical information, etc).

3.2.1. Location analysis

A study of the acoustic suitability of the location of the noise monitoring terminals has been carried out, considering the following aspects:

- Low residual sound (maximum sound pressure level of the quietest aircraft should be at least 15 dB greater than the residual long-term-average sound pressure level) Figure 2.

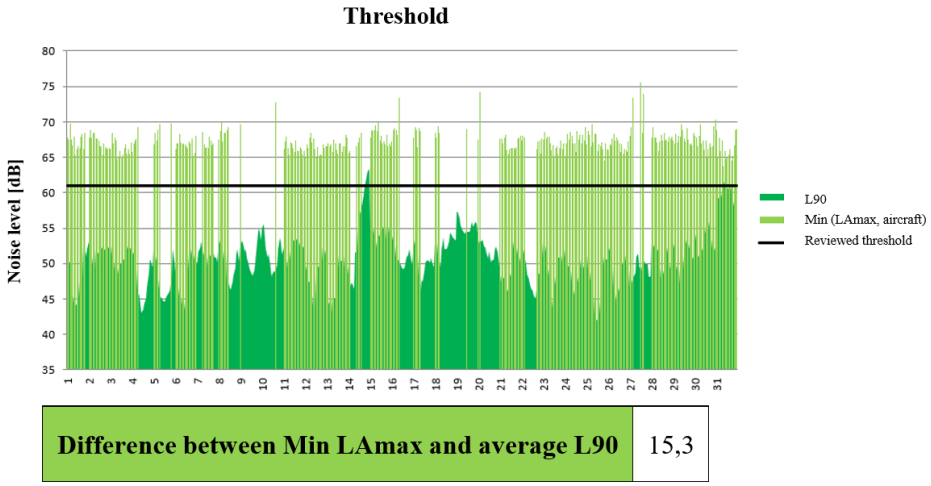


Figure 2. Residual Sound – Quietest aircraft evaluation

- Measuring height to 6 m (Figure 3)
- Relevant reflecting surfaces other than ground shall be at least 10 m away (Figure 3)

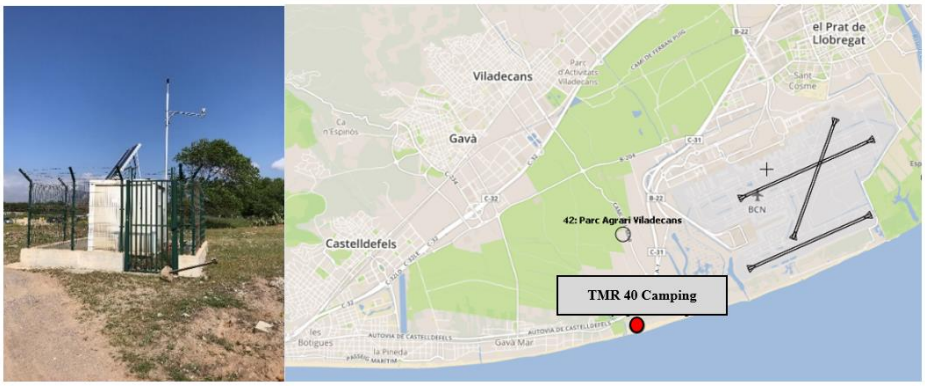


Figure 3. NMT Location example

- Elevation angle should be greater than 30 degrees (Figure 4)

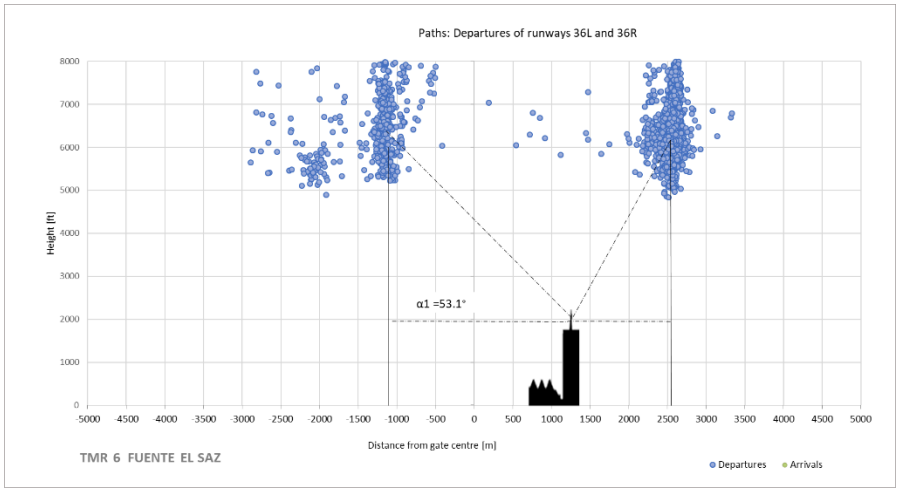


Figure 4. Elevation angle analysis

- The sector should be free of obstacles (Approx. 140 degrees)
- Weather information, minimum wind speed

The NMT location is suitable just if all the requirements are achieved. If one or more requirements are not achieved, NMT location is not suitable or the data uncertainty increases.

These criteria were evaluated and analyzed in each NMT location included on the accreditation, making the appropriate modifications to adjust to the standard.

Some issues were detected on the application of these requirements:

- The measuring height is established at 6 meters, but this height has two main disadvantages. The first one lies in the technical difficulties involved in installing a measurement microphone at that height, considering safety reasons when performing maintenance tasks and annual equipment verifications. On the other hand, and acoustically more relevant, the current Spanish legislation [11] defines the Acoustic Quality Objectives at 4 meters above ground level, and this discrepancy of 2 meters, added to the fact that aeronautical noise measurements are rarely performed at street level, precludes the verification of the acoustic quality objectives if the measurements are carried out in accordance with ISO 20906.
- It is established that the weather stations must be installed at least 1 meter below the microphone and 1,5 meters in horizontal distance. Due to the current characteristics of the weather stations, it does not have any acoustical sense to establish that distance since currently these equipments do not have any mobile part that can generate any kind of noise.
- It is established that the elevation angle from the microphone to the aircraft must be at least 30 degrees to minimize the effects of the ground reflections. This criterion restricts the area where the NMTs can be installed since it restrings the areas near the airport and / or parallels to the runways, for obvious

reasons. In addition, this angle can change depending on the configuration and / or the runway used.

3.2.2. Data validation

To guarantee the quality of the final data, a daily manual revision is done completing the automatic process carried out by the system. The following aspects are reviewed deeply:

- High percentage of correlation Operations / Noise events (correlation ratio greater than 50%)
- Data availability greater than 70% by noise terminal
- Noise events with a wind speed greater than 10 m/s
- Grooming of correlations due to suspicious contaminated events
    - Long events
    - High level noise events
    - High SEL levels

3.2.3. Uncertainties calculation

There are different methodologies for the estimation of measurement uncertainty. In this procedure it is used the ISO/IEC Guide 98-3:2008 standard [8]. Following this method, the uncertainty of the result of a measurement comprises several components that can be grouped into two categories, depending on the method used for the estimation of its numerical value:

- Type A: Those that are estimated by applying statistical methods to a series of independent repeated measurements under the same measurement conditions.
- Type B: Those that are estimated by other different means than statistical analysis.

It has been established a model for calculating uncertainties for the following cases, taking into account the considerations of ISO 20906 and ISO 1996-2:2017 Acoustics - Description, measurement and assessment of environmental noise - Part 2: Determination of sound pressure levels [6].

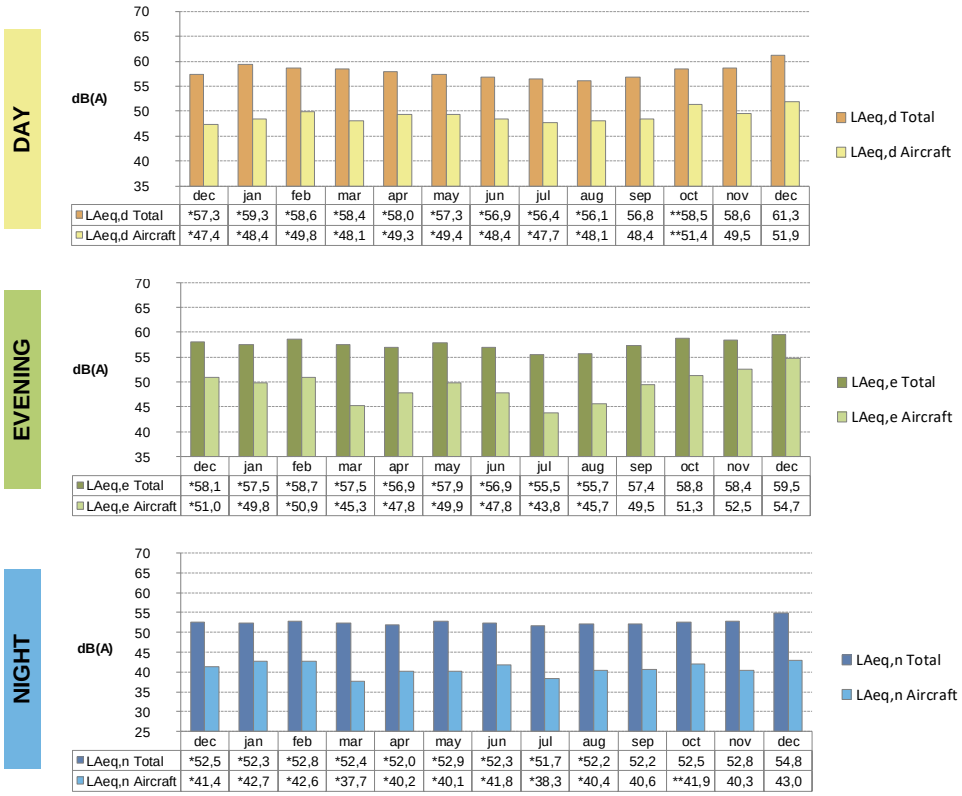
- Uncertainty for individual aircraft noise events (L_E, L_{Amax} indicators): components of the uncertainty such as the associated with the measurement equipment or the background noise.
- Uncertainty for accumulation of aeronautical noise events ($L_{Aeq,Avion}$ indicator): components of the uncertainty such as the associated with the measurement equipment, variation on the sound source emission and effects of the weather conditions on the propagation, influence of the residual noise, microphone location, detection errors and event classification.
- Uncertainty for the calculation of the total noise levels (L_d, L_e, L_n indicators): components of the uncertainty such as the associated with the measurement equipment or the microphone location.

Difficulties on the application of the standard

- There are some locations that are only affected by an airport configuration, in other words, a great part of the time could have a low number of operations that means few samples for the calculation of the uncertainties. The result of this is an increase in the uncertainly of the measurement that makes it difficult to obtain aircraft noise levels with an uncertainty lower than 3 dB despite having measured all the available samples.

3.2.4. Reports

The ISO 20906 standard establishes the minimum content that aeronautical noise reports should have. In addition, the ISO 17025 standard establishes the format to be followed by the reports, the technical aspects that they should contain, the clarifications, etc. so that the report is not only technically valid but also meets the necessary quality requirements that ensure its clear and unambiguous interpretation. An example of noise accredited report is showed in Figure 5.



	dec	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
LAeq,d Total	*57,3	*59,3	*58,6	*58,4	*58,0	*57,3	*56,9	*56,4	*56,1	56,8	**58,5	58,6	61,3
LAeq,d Aircraft	*47,4	*48,4	*49,8	*48,1	*49,3	*49,4	*48,4	*47,7	*48,1	48,4	**51,4	49,5	51,9

	dec	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
LAeq,e Total	*58,1	*57,5	*58,7	*57,5	*56,9	*57,9	*56,9	*55,5	*55,7	57,4	58,8	58,4	59,5
LAeq,e Aircraft	*51,0	*49,8	*50,9	*45,3	*47,8	*49,9	*47,8	*43,8	*45,7	49,5	51,3	52,5	54,7

	dec	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
LAeq,n Total	*52,5	*52,3	*52,8	*52,4	*52,0	*52,9	*52,3	*51,7	*52,2	52,2	52,5	52,8	54,8
LAeq,n Aircraft	*41,4	*42,7	*42,6	*37,7	*40,2	*40,1	*41,8	*38,3	*40,4	40,6	**41,9	40,3	43,0

* Data prior the accreditation

** Non-valid data for having less than 70% available data

Figure 5. Monthly accredited noise levels report

At the time of applying the ISO 20906 standard, some discrepancies have been found with respect to Spanish legislation. In RD 1367/2007, it is established that L_{AFmax} must be used in the evaluation and measurement of aeronautical noise. However, ISO 20906 defines L_{ASmax} and $L_{Aeq,1s,max}$ as the most appropriate indicators for aeronautical

noise measurements. In this case, we have adjusted to the reference standard by using an indicator more appropriated for aeronautical noise measurement, being this an accreditation scope.

3.2.5. Quality assurance

In order to meet the quality requirements of the ISO 17025 standard, the following aspects should be periodically verified:

- Qualified technicians
- Data traceability
- Internal and external audit
- Intercomparison
- Training and supervision

The revision of these aspects means a quality assurance on the process controlled both internally and externally. The external controls are based on the on-site verification by an entity external to the company activity on the following aspects:

- Staff expertise and experience
- Methods and procedures according to ISO 17025 and ISO 20906
- Appropriate equipments
- Appropriate noise measurement locations
- Data quality
- Traceability
- Report quality

4. RESULTS

After the audit phase and once the non-conformities detected are solved by the audited team, the evaluation commission decides whether or not the grant accreditation.

If the result is successful, the entity can show the accreditation number on its reports or in the data. An example of a report is shown in Figure 6.

Figure 6. Accredited report example

This supposes an increase in the data credibility and the standardization of methodologies and reports.

Finally, in order to achieve the social acceptance of the airport environment and to improve the relation with the communities, the accreditation supposes an increase of the confidence in the results provided by the system, since it is data managed by a company independent from the airport and accredited by a third independent party according to the quality standards.

The accreditation is the international tool used to generate confidence in the correct performance of a very specific type of activity (Unattended monitoring of aircraft sound) named Conformity Assessment Activities. The following aspects are assured:

- To have staff with the appropriate expertise and experience.
- To have the necessary and appropriate equipment and infrastructures to carry out their activities.
- To apply appropriate and valid assessment methods and procedures.
- To employ techniques to assess the quality of results and ensure the traceability of the measurements associated with their services.
- To give enough information to their clients on the results of their activities, issuing clear and precise reports or certificates.

4. CONCLUSION

The accreditation process implies a normalization and adaptation of the internal processes in accordance with the technical and quality criteria, being this a very positive performance for a measurement laboratory concerned about the veracity of the results.

The application of the ISO standard presents some technical difficulties in relation with the requirements of the measurement locations and the installation of complementary equipment, in some cases due to physical aspects such as the elevation angles and in other cases due to coherence absence with the Spanish legislation.

The accreditation improves the confidence of the noise data published by the airport manager that is available also for the municipalities and communities. This shows transparency and implies an added value, since the data is provided by an external company and the procedure of acquisition and reviewing the data have been validated by an external accrediting entity.

5. ACKNOWLEDGEMENTS

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6. REFERENCES

1. ACI (Airports Council International), “Addressing the future of aviation noise” (2018)
2. Directive, E. U. "Directive 2002/49/EC of the European parliament and the Council of 25 June 2002 relating to the assessment and management of environmental noise." Official Journal of the European Communities, L 189.18.07 (2002)
3. EASA (European Union Aviation Safety Agency), European Aviation Environmental Report (2019)
4. European ATM stakeholders, European CCO and CDO Task Force Report (2018)
5. ISO/IEC 17025. "General requirements for the competence of testing and calibration laboratories." International Organization for Standardization (2017).
6. ISO 1996-2 “Acoustics -- Description, measurement and assessment of environmental noise -- Part 2: Determination of sound pressure levels”. International Organization for Standardization (2017).
7. ISO 20906. "Acoustics--unattended monitoring of aircraft sound in the vicinity of airports” International Organization for Standardization (2009).
8. ISO/IEC. "Guide 98-3 (2008) Uncertainty of measurement—Part 3: guide to the expression of uncertainty in measurement (GUM: 1995)."
9. Miedema, H. M., and C. G. Oudshoorn. "Annoyance from transportation noise: relationships with exposure metrics DNL and DENL and their confidence intervals." Environmental health perspectives 109.4 (2001): 409-416.
10. Nelson, Paul M. "Transportation noise reference book." (1987)
11. Real Decreto 1367/2007, de 19 de octubre, por el que se desarrolla la Ley 37/2003, de 17 de noviembre, del Ruido, en lo referente a zonificación acústica, objetivos de calidad y emisiones acústicas. BOE nº 254. de 23/10/2007. http://www. boe. es/buscar/act. php, 2007.
12. Schultz, Theodore J. “Community noise rating”. Elsevier Applied Science (1982)
13. World Health Organization. "Environmental noise guidelines for the European Region." (2018)