

# Environmental Noise - Integrating and sharing geographic data sets

## Ruido ambiental - Integración y uso compartido de conjunto de datos geográficos

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### Abstract

Noise is a major environmental concern. To address this issue, the European Commission (EC) launched the Environmental Noise Directive (END), whose main objective is to assess and manage noise from various sources, including airports, roads, railways and agglomerations.

An effective implementation of END requires the harmonisation of data supplied by various national agencies such as municipalities and airport authorities.

This paper presents the Portuguese approach to the harmonization of data, as part of the END implementation, which was coordinated by the Portuguese Environmental Agency (APA).

It also describes a set of principles and procedures developed by APA to ensure data harmonization and integration in a single platform, which provides interoperable information to decision makers, key stakeholders and general public, through Web Services.

### Resumen

El ruido es una de las principales preocupaciones medioambientales. Para hacer frente a este problema, la Comisión Europea (CE) ha puesto en marcha la Directiva sobre el Ruido Ambiental (END), cuyo principal objetivo es evaluar y gestionar el ruido procedente de diversas fuentes, como aeropuertos, carreteras, ferrocarriles y aglomeraciones.

Una aplicación eficaz de la END requiere la armonización de los datos proporcionados por diversos organismos nacionales, como los municipios y las autoridades aeroportuarias.

Este documento presenta el enfoque portugués para la armonización de datos, como parte de la implementación de la END, que ha sido coordinada por la Agencia Portuguesa de Medio Ambiente (APA).

También describe un conjunto de principios y procedimientos desarrollados por la APA para garantizar la armonización e integración de los datos en una plataforma única, que proporciona información interoperable a los responsables de la toma de decisiones, a las principales partes interesadas y al público en general, a través de los servicios web.

**Keywords:** Agência Portuguesa do Ambiente, SNIAmb, Environmental Noise, Data harmonization, Geospatial Web Services, Noise Spatial Data Infrastructure, Environmental Noise Directive, END, INSPIRE

**Palabras clave:** Calibración, Espacios de color, Perfiles de color, ICC, International Color Consortium, Gamma, Brillo, Contraste, Tonalidad, Saturación, CIE.

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## 1. INTRODUCTION

Noise is a growing environmental concern and a major issue behind the degradation of people's well-being, with direct and cumulative adverse impacts on human health and significant impacts on quiet natural areas that need to be preserved.

Noise pollution and its control has been a concern for authorities and the target of several regulations. END (Directive 2002/49/EC) is Europe's main instrument to identify and assess noise exposure levels, and trigger actions to prevent and reduce noise to acceptable values. To achieve these goals, END defines a common approach and harmonizes indicators and noise assessment methods.

END requires member states to identify noise sources above certain thresholds, and prepare Strategic Noise Maps (SNMs) and Noise Action Plans (NAPs). SNMs are noise diagnosis and management tools that allow the spatialization of noise levels and identification of critical areas, and NAPs provide a framework to manage noise issues and ensure the protection of quiet areas. It is mandatory to report this information to the EC, through a digital information exchange mechanism every 5 years.

To implement END, the EC is supported by the European Environment Agency (EEA), which is in charge of collecting all the information submitted by the member states and making it available through the Noise Observation and Information Service for Europe (NOISE). END was transposed to Portuguese legislation in 2006 (Decreto-Lei 146/2006). This legislation defines noise pollution prevention and control as key objectives for safeguarding health and the environment. Also relevant to implement END is the INSPIRE directive (Directive 2007/2/EC), which establishes common rules and principles to ensure interoperability and accessibility of geospatial data related to the environment.

Since 2022, the European Environmental Information and Observation Network (EIONET) requires the report of geospatial data through a new infrastructure, Reportnet3.0, which uses GeoPackage format for all geospatial dataflows. This format is open, non-proprietary, and platform independent.

INSPIRE and Reportnet3.0 provide an essential framework for implementing END. However, two main challenges remain: 1) data produced by a variety of national entities must be harmonized and integrated into a Spatial Data Infrastructures (SDI); and 2) integrated data must be made available to the EC, stakeholders and general public through Web Services.

In Portugal, APA is the public entity that coordinates the implementation of END. The project relays various national agencies related to public infrastructures (Infraestruturas

de Portugal), airport management (ANA Aeroportos de Portugal), local authorities (e.g., municipalities of Lisbon and Porto), and regional governments (Madeira and Açores islands). All these agencies must identify noise sources (major roads, railways, airports and industrial sites). These agencies also have to estimate the number of people exposed to potentially harmful noise levels and produce SNMs and NAPs.

The main goal of this paper is to discuss how APA harmonizes and integrates the data supplied by the abovementioned agencies, in the context of END.

The paper is structured as follows. The following section discusses the main project's concern, i.e., environmental noise. Next, the national and European contexts of the project are discussed. Finally, it addresses how data harmonization and integration were accomplished.

## 2. ENVIRONMENTAL NOISE

When a sound is unwanted, unpleasant, excessive or prolonged, it becomes noise. Noise is currently a major environmental problem and one of the main causes of the degradation of quality of life, especially in large urban areas.

According to the World Health Organization (WHO), long-term exposure to environmental noise is associated with an increased risk of negative physiological and psychological health outcomes (WHO, 2018). Auditory effects of noise include hearing impairment and tinnitus, while nonauditory effects include cardiovascular and metabolic effects, birth complications, poor quality of life, mental and well-being issues, annoyance, cognitive impairment and poor sleep (EEA, 2019).

Available data on long-term noise exposure shows that 65 % Europeans living in major urban areas are exposed to daytime noise levels above 55 dB, and more than 20 % are exposed to night-time noise levels above 50 dB, which are often associated with adverse health effects (Jarosińska, D. et al., 2018).

To reduce noise pollution and the number of people exposed to harmful noise levels, it is essential to identify the main noise sources and assess their exposure levels. These elements are required to produce SNMs and NAPs.

As noise sources, END considers: 1) industrial sites, major roads, railways and airports inside major agglomerations; and 2) major roads, railways and airports outside major agglomerations (Peris, E. et al., 2020). The thresholds for each source are summarized in Figure 1.

END requires member states to report noise data in digital format, using different data models. In this paper, the focus is on geospatial dataflows, specifically DF1 5, for noise sources, and DF4 8, for SNMs and exposure values.

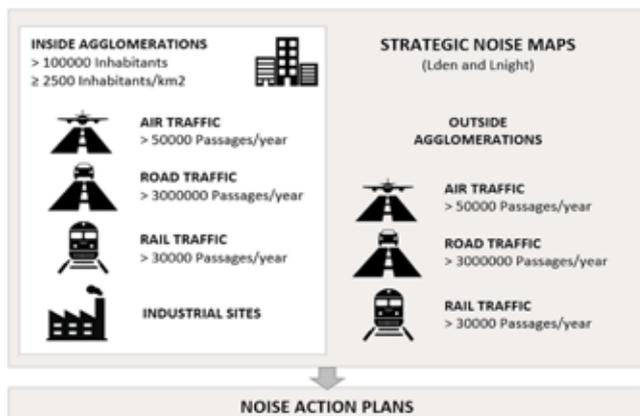


Figure 1. Noise sources under END directive

DF15 handles data related to: major agglomerations, their size and number of inhabitants; major roads and railways, their length and annual traffic; and airports including annual traffic. DF4 8 handles data related to noise levels and the number of people exposed to harmful noise levels for Lden and Lnight periods (Blanes, N. et al., 2022). Lden is the indicator for the day-evening-night period and represents noise levels resulting from the sum of the contribution of all noise sources, for all periods of the day. Lnight is the indicator for the night period and represents noise levels resulting from the sum of the contributions from all noise sources for the night period (23:00 to 7:00) (EEA, 2019).

The data schemas defined for these dataflows must be INSPIRE-compliant and reported through Reportnet 3.0, using GeoPackage format.

### 3. PORTUGUESE CONTEXT

In Portugal, the END implementation has been assigned to APA, which acts as coordinating agency and EEA national focal point, with all other agencies participating as data suppliers.

APA created a technical support group in the Information Systems Division (DSI) with the specific goal to specify, implement and test the data harmonization for DF1 5 and DF4 8. The project also included the development of technical guides, videos, workshop, and examples with fictitious data, which were specifically created for the purpose to explain the implementation process. Whenever possible, materials made available by EEA were reused.

Considering the high number of stakeholders involved in the process, APA decided to implement the DF1 5 dataflow, entrusting the other agencies to harmonize and validate DF4 8 data, using the best

practices defined by APA.

The DF1 5 dataflow includes Lisboa and Porto major airports, Lisboa, Amadora, Odivelas, Oeiras, Porto and Matosinhos major agglomerations, plus numerous major railways (mainland) and roads (mainland, Madeira and Açores islands), which are identified in Figure 2. Major airports and agglomerations are already reported to the EC.

DF4 8 data, harmonized by data producers, must be validated to ensure compliance with END, INSPIRE and APA’s guidelines. To this end, DSI developed the validation process illustrated in Figure 3, which includes two flows: one is performed by the data producers, using Reportnet; and the other performed by APA’s lead reporters, using Reportnet and internal Map Viewers. END/INSPIRE compliance is validated through Reportnet, and APA’s guidelines compliance (e.g., nomenclature, geometry and reference data) is checked through Map Viewers.

The Reportnet validation process involves several levels (Blanes, N. et al, 2022), including cross-validation between different dataflows, which ensures that the data reported under DF1 5 is consistent with the data reported under DF4 8 (Figure 4).

Once harmonization and validation are completed, the supplied data can be reported to the EC and integrated in the Portuguese environment SDI (SNIAMB).



Figure 2. Portuguese noise sources under DF1 5 dataflow

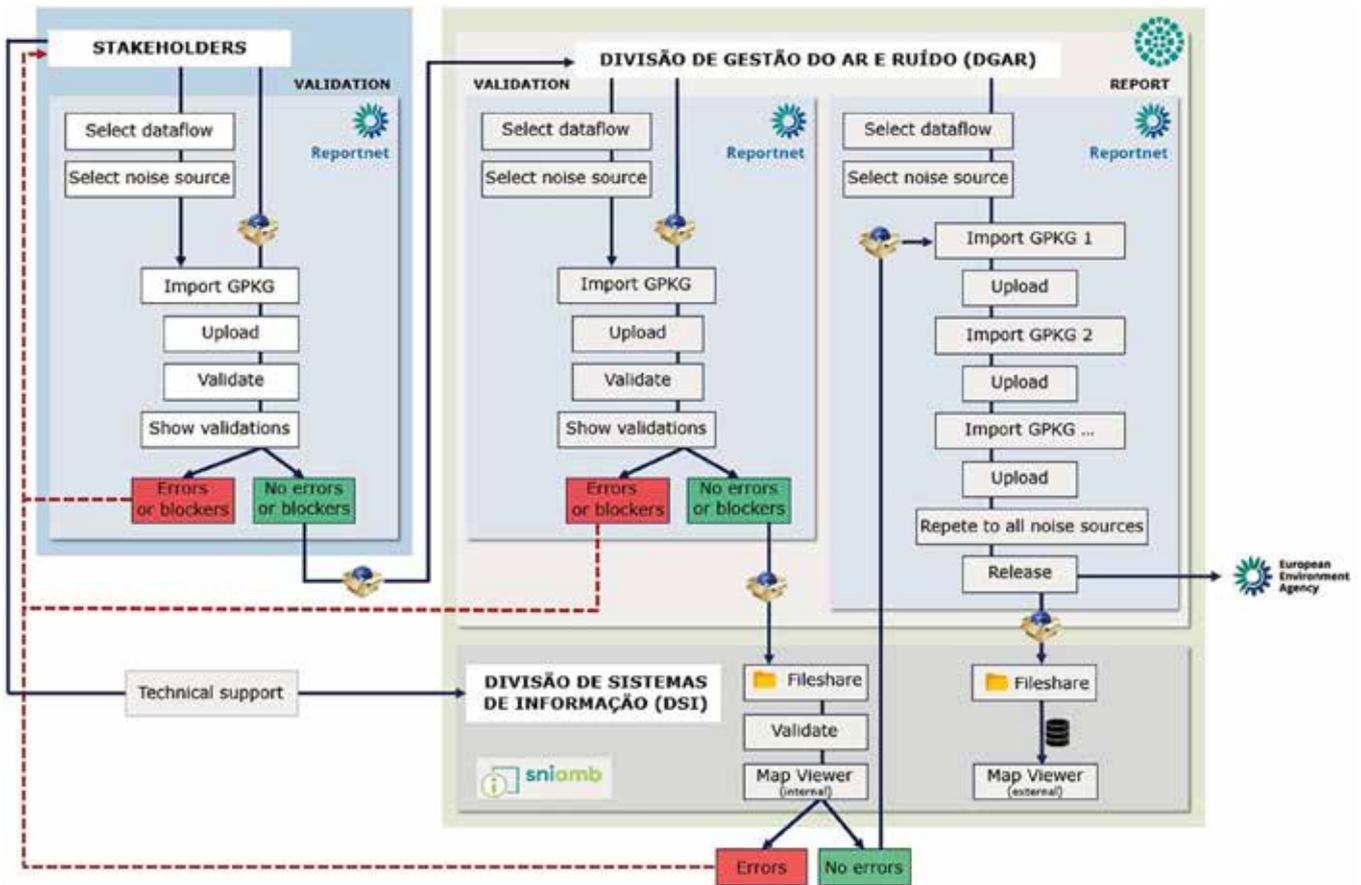


Figure 3. Validation flow implemented by DSI



Figure 4. Reportnet validation

## 4. END/INSPIRE CONTEXT

DF1 5 and DF4 8 dataflows are aligned with the INSPIRE Directive, as illustrated in Figure 5 (Reitz, T., 2021). Major airports, roads and railways END themes correspond to the Transport Networks INSPIRE theme, from Annex I. Major agglomerations correspond to the Management/Restriction/Regulation Zones and Reference Units INSPIRE theme, from Annex III. Major airports are reported using point-type geometry, major roads and railways using line-type geometry and major agglomerations using polygon-type geometry.

SNMs correspond to the Human Health and Safety INSPIRE theme, from Annex III, and can be reported using polygons or lines. However, APA opted for polygon geometry. Exposure data does not fall within the scope of INSPIRE.

## 5. DATA HARMONIZATION

Data harmonisation involves the transformation of data from different sources, formats, semantics and structures into standardised data schemas.

Harmonisation is a time consuming and demanding process, which requires detailed knowledge about the domain, data source and target schemas. However, this procedure is facilitated with the use of END compliant GeoPackage schemas.

In this project, the harmonization process involves mapping a set of attributes from the source model, in shapefile and excel formats, to the corresponding target model, in GeoPackage format (Figure 6), using hale»studio application.

DSI pre-tested the harmonization of DF1 5 and DF4 8 data for all noise sources, using fictitious data. Based on the pre-tests, it was possible to harmonise and officially report DF1 5 airports and agglomerations data. APA will harmonize and report DF1 5 roads and railways, as soon as the respective



Figure 5. Match between END and INSPIRE themes



Figure 6. Data harmonization process

competent authorities provide these data. DF4 8 data harmonisation is being ensured by data producers and should be reported by the end of this year.

Figure 7 illustrates the GeoPackage structure for major airports, based on the Unified Modelling Language (UML) data model for DF4 8 (Blanes, N. et al., 2022). This model includes a spatial component for Lden and Lnight indicators, and a non-spatial component for exposure data.

Figure 8 illustrates the overall transformation applied to DF4 8 major airports. In some cases, the correspondences are simple and straightforward, requiring only renaming the attributes to comply with the required semantics. However, in other cases, it is necessary to reclassify several attributes, as is the case of the category field. Moreover, the target schema requires new fields, which do not exist in the source schema. Some are created through the assign function, such as the source field, and others can be derived from the source schema, using the formatted string function.

Figure 9 shows the hale»studio interface with the source schema on the left and the target schema on the right. The Lden spatial feature, on the source, is uploaded with 9 non-harmonized noise level polygons that were transformed into 9 harmonized noise level polygons, on the target schema, as required by END Lden noise level codelists. The ExposureValue table, on the source schema, contains 602 non-harmonized noise exposure records (per Local Administrative Unit), which were transformed into 602 harmonized records. Tables DatasetDefaultProperties and CodelistProperties, on the target schema, are already prefilled.

Throughout the harmonization process, hale»studio



Figure 7. GeoPackage structure for DF4 8 major airports

provides geospatial and tabular overviews of the source and target schemas (Figure 10). Hale includes validation rules that impose some restrictions, such as the use of specific codelists supplied by END. It also includes a Report List tool, which lists all the procedures applied for data harmonization and indicates errors or warnings, whenever detected.

Harmonized data is then exported to the GeoPackage format for Reportnet validation, which ensures that the END requirements are fully complied.

## 6. DATA INTEGRATION AND SHARING

Once validation is completed, the information produced by the agencies is integrated into the national environment SDI (SNIAmb), and is made available through Web Services (Figure 11). This information can be reused by the stakeholders.

It is intended that SNIAmb is fully aligned with the END and INSPIRE directives and hale»studio and Reportnet3.0 give assurances regarding compliance.

END data collection and reporting to the EC make it possible to create an european SDI. They also allow to develop products such as the one presented in Figure 12, which is a Story Map about noise and its effects on european citizens (EEA, 2017), where it is possible to obtain comparable data across EU.

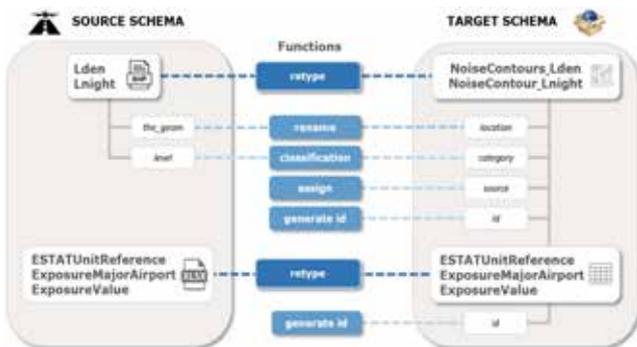


Figure 8. DF4 8 major airports transformation

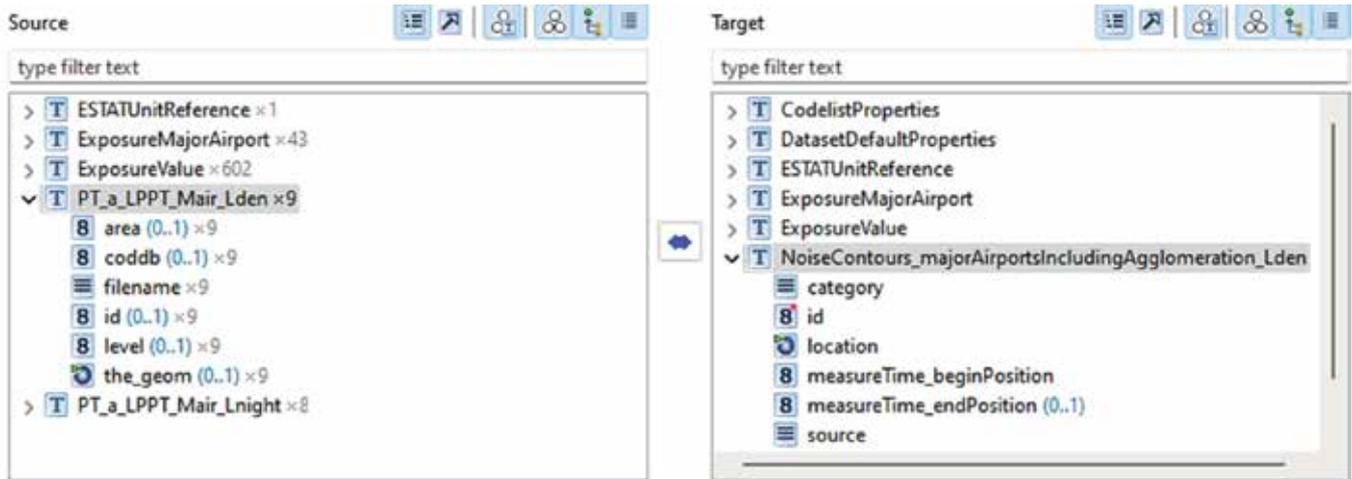


Figure 9. Halestudio interface showing source and target schemas

## 7. RESULTS

The methodology and processes defined by this project have proven effective to obtain END/INSPIRE compliant Portuguese datasets for DF1 5 and DF4 8 dataflows, for each noise source.

APA has implemented this methodology to harmonise, validate and officially report DF1 5 data from major airports and agglomerations.

This methodology is currently being implemented, by the data producers, for DF4 8 dataflow. The deadline for this dataflow is December 31, 2022.

The main outcome from this project is a single platform with integrated and standardised data about noise. Without END noise data would be dispersed and difficult to access.

## 8. FINAL REMARKS

The main problem address by this project was the articulation between APA and the various agencies involved in the identification and analysis of noise sources and the difficult communication between noise and GIS/harmonization experts.

Equally relevant was the lack of knowledge and experience with the use of hale»studio application,

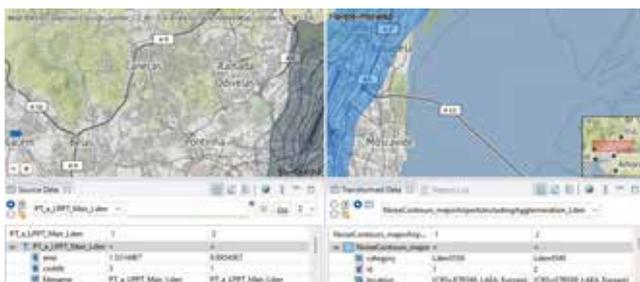


Figure 10. Geographic and tabular overviews of source and target schemas

familiarity with GeoPackage format, and the requirements of the INSPIRE themes covered.

DSI has developed a methodology and a set of processes, which have been made available to stakeholders. However, there is still a huge reluctance to follow the recommended methodology.

Given the proximity of the deadline to implement DF4 8 dataflow, there is a serious risk of defaulting compliance with the END directive. In addition, the risk of failure is exacerbated by the fact that DF1 5 noise sources is not yet completed (major roads and railways have not yet been implemented).



Figure 11. Portuguese environment SDI (SNIAmb)

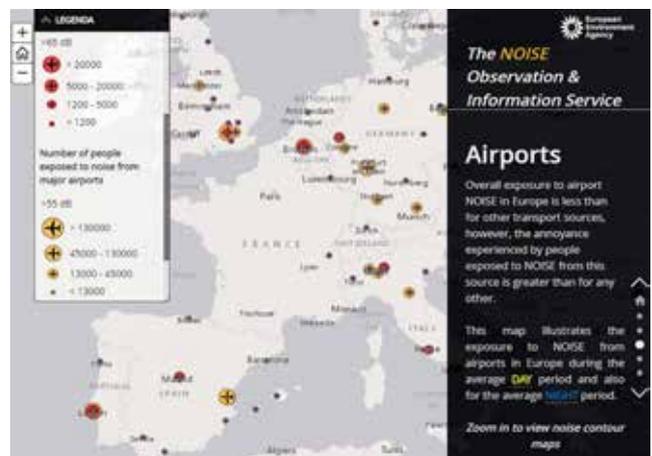


Figure 12. The NOISE Observation & Information Service

The authors hope that this project will contribute to the fulfilment of END's obligations, under the current round.

## ACKNOWLEDGMENT

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### About the authors

#### The Portuguese Environment Agency

*The Portuguese Environment Agency (APA) is the entity responsible for the implementation of environmental policies in Portugal. APA aims to contribute to a high level of protection and enhancement of the environment through the provision of quality services to citizens.*

*The Portuguese Environment Agency is a public institute integrated in the indirect administration of the State, under the supervision of the Ministry of Environment and Climate Action and endowed with administrative and financial autonomy and its own assets.*

*The APA is the result of the merger, in 2012, of the Portuguese Environment Agency, the Water Institute, the 5 Administrations of the Hydrographic Region, the Commission for Climate Change, the Waste Management Monitoring Committee and the Environmental Emergency Planning Commission.*

*The APA has its headquarters in Amadora and 5 Administrations of Hydrographic Region (ARH) deconcentrated in the territory of mainland Portugal: ARH do Norte, ARH do Centro, ARH do Tejo e Oeste, ARH do Alentejo and ARH do Algarve.*