Low-Cost Geographic Information System for Municipal Road Signs Management in Depopulated and Low-Density Areas

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Abstract. The current national and regional economical conjuncture in many countries, requires a sustainable management of different urban infrastructures, including road signs. From the set of possible solutions to improve the existing infrastructure’s management, analysis and spatial representation, Geographic Information Systems (GIS) have proved to be an essential tool for the functional competencies of local administration (municipalities), managers of municipal road networks. This study presents a framework of existing national regulations on road signs, as well as the shortcomings in the definition of methodologies for GIS-based management systems implementation. The paper continues with the critical assumptions considered in their definition and the municipalities specific competences needed for their implementation. A low-cost methodology is proposed and applied to a case study in a small Portuguese village: Belmonte. The results have shown the potential of these low-cost systems, revealing relevant time and economical gains, providing municipalities with fundamental information for the definition of realistic and well-founded strategic plans and budgets, and allowing better information to their citizens. The gathered information can help in inventory, inspections, maintenance and replacement allowing detailed reports and geo-referenced electronic database and maps of a municipality’s road signs at reasonable costs. These maps and reports are the starting point to forecast the projected lifespan of the municipality’s signage allowing more accurate project sign management budgets for future years. Aspects that need further development in order to improve the proposed system are also addressed.

1. Introduction
The standardization of traffic signs in Europe started in 1931 with the Geneva Convention concerning the Unification of Road Signals by several countries. The 1931 Convention rules were further developed in the 1949 Geneva Protocol on Road Signs and Signals. In 1968 many European countries signed the Vienna Convention on Road Traffic treaty, with the aim of standardizing traffic regulations
to improve international road traffic and to increase road safety. Part of the treaty was the Vienna Convention on Road Signs and Signals, which defined the traffic signs and signals. As a result, in Western Europe the traffic signs are well standardized, although there are still some country-specific exceptions. European traffic signs have been designed to ensure that signs are clear and understandable immediately. Most traffic signs conform to heraldic tincture rules and use symbols rather than written texts for better semiotic clarity. In order to make it as universal as possible, the convention allows some variations, for example danger warning signs can be triangular or square diamond in shape and road markings can be white or yellow. Though most United Nations members have not ratified the full treaty, the signs and legal principles in it form the basis of traffic law in most worldwide countries.

Road signs, or traffic signs, are a relevant aspect in regularizing traffic, indicating to users of public roads the correct and safe way in which they can be used. According to Roque [1] and AFESP [2] the legibility of the public road can be defined as the property to transmit to users a correct, clear and quickly understandable image of its nature, type of use, possible movements or other users, in order to adapt a correct behaviour when circulating. Good legibility allows a good adaptation of users’ general behaviour to prevailing conditions, namely speed, for an adequate anticipation of road events, limiting the risk of accidents. In order for the signage to contribute effectively to this legibility, particularly in urban areas, it must be appropriate to the road’s hierarchical level and be consistent with the surrounding environment [1, 2]. Good signage must also consider essential characteristics for easy interpretation by all road users, namely:

- Uniformity: a necessary condition for its understanding by all;
- Homogeneity: allowing the driver to understand the context in which he is driving;
- Simplicity: facilitating the driver's understanding;
- Continuity: ensuring integration with the rest of the signs, namely the orientation sign;
- Coherence: with practice and traffic rules.

Traffic signage, in general, can be done through traffic signs, including temporary signs, signs of traffic regulating agents, or by driver signals. Traffic signs include vertical signs, road surface marks, and light signals (like traffic lights or variable message signals). Vertical signs are divided into three basic categories: Regulatory, Warning, and Guide signs. Traffic signage, however, obey a hierarchy of prevalence over each other. The regulation resulting from traffic signs prevails over general traffic rules, but traffic signs generally obey the following hierarchy [3]:

1. Orders by traffic regulating agents precede over all traffic signs and traffic rules;
2. Temporary signage prevails over other signs and normal road use rules;
3. Regulations resulting from light signals;
4. Regulations resulting from vertical signs;
5. Regulations resulting from road surface marks;
6. General traffic rules.

Signage alone is not enough to guarantee road legibility, but it can make a significant contribution [2], increasing the probability of avoiding serious accidents and enhancing traffic safety, particularly in urban areas where the probability of road conflicts is higher. A system to manage such an amount of information cannot be done by traditional means. Bigger cities generally have larger budgets that allow the implementation of more sophisticated information and data management systems (even commercial software). But smaller cities, despite having less information to manage, still have difficulties to manage it and generally spend their low budgets with other priority issues. Current commercial management systems, available in the market, generally have costs that small municipalities cannot afford.
The present study, therefore, arises from the necessity of define a low-cost methodology to quantify and qualify road signs in low density areas. In view of the time and budget limitations, this preliminary study was limited only to vertical signs and traffic lights, but the suggested methodology can be extended to the remaining road signs, with adaptations.

The proposed methodology was defined taking into account the following premises:
- Allow the management of information and its quick update;
- Design in an open-source GIS software, to register all the necessary information for the road sign set characterization;
- Easy access to each road sign set data;
- Allow register and monitoring of inspections, repairs and replacement works required in the road sign set;
- Allow collection of basic data for the definition of maintenance plans and more accurate municipal budgets;
- To serve as a starting point for the definition of a municipal road signs regulation, with thematic cartography;
- Allow the assessment of compliance with legal and regulatory requirements within the jurisdiction of municipalities, regarding to road signage.

The study also intended to evaluate the strengths and weaknesses of the suggested methodology for the management of road signs in a low-density urban environment.

1.1. Traffic safety in Portugal

The general evolution of road accidents in Portugal presents an improvement in the last decade. However, with a more detailed analysis, it is possible to conclude that this trend has not been confirmed in recent years. In figure 1 it is possible to see that the total number of accidents with casualties has been around 33500 since 2016 (only 2020 has a relevant decrease to around 23500 due to COVID-19 lockdown and traffic restrictions).

![Number of accidents per road type in Portugal](image)

**Figure 1.** Road accidents in Portugal between 2016 and November 2020 [2, 4]
The same pattern can be seen in the number of casualties, either fatal, serious or light. The analysis also reveals that most of the accidents (around 82%) occur in urban and national roads, which have the longest network (thus more exposure). Accidents in urban roads represent around 62% of all accidents, but only 33% of fatal and 45% of sever casualties. Accidents on urban roads, although in greater numbers, are less serious probably due to lower traffic speeds. When analysing the data for urban areas, the percentage of fatal casualties in urban roads increases to 65% and sever casualties to 74%. A survey conducted by AFESP in 2020 [2] about the relevance on traffic signage in Portugal, revealed that vertical signs were the most relevant issue in normal visibility conditions and road surface marks in conditioned visibility. Although most of the population considers that road signs are visible, 20% considers that the signage visibility should be improved. The survey also points out that heavy vehicle drivers consider road marks as less visible (58% are "Poorly visible" and 15% "Nothing visible"), and 52% consider vertical signs “Poorly visible”. In the same study for Municipal Roads (including urban roads), surface road marks and vertical signs were the types of signage that presented a worse state of conservation. These number show the potential that road signs can have in improving safety (and its perception) and the relevance of their correct management and maintenance.

1.2 Traffic regulations and design norms
In order to improve the roads’ legibility and its perception from all road users (drivers and the population in general), there is a need to improve and innovate road traffic support infrastructures, particularly in urban areas. These infrastructures, namely the traffic signs, should favour an early road legibility. This can only be achieved through well implemented and designed signage, developed by specialists and defined on regulations that clearly specify its correct placement and usage. Traffic signs’ design is internationally accepted and relatively uniformised, but the specialists legibility particularly in urban areas. These infrastructures, namely the traffic signs, should improve the roads’ perception and its correct maintenance.

According to the CCDRN [5], the Portuguese national regulation on road signs comprises the following official documents: Road Traffic Code (RTC), Traffic Signal Regulation (TSR), Road Surface Marks Standard (RSMS); Vertical Signalling Standard (VSS); Orientation Vertical Signalling Standard (OVSS); Tourist Signalling Standard (TSS); and Temporary Signalling Manual (TSM).

The Institute for Road Infrastructures (INIR), since 2012 included in the Institute for Mobility and Transport (IMT), also published some normative documents to technically guide and assist technicians in the development of signage projects. Among other the IMT published: Highway Traffic Signals (HTS), Roundabout Signalling (RS), Crossroads and Junctions Signalling (CJS), Orientation Signalling - Information System (OS), Technical Instruction on the use of Variable Message Signs (TIVMS), Vertical Signalling – Features, (VS), Principles of Traffic Signalling and Circulation Regimes (PTSCR), Vertical Signalling - Usage Criteria (VSUC), Vertical Signalling - Placement Criteria (VSPC) and Road Surface Marks - Dimensional Characteristics, Criteria and Placement (RSM).

With all these regulatory elements, it would be expected that there would be fewer problems in the implementation of traffic signage and in its correct maintenance. Many of the problems encountered stem from the confusion as to which entity has competence to implement traffic signs as well as the qualifications and constitution of the implementation teams.

In 1998, the Portuguese “Traffic Signalling Regulation” [6] stated in its 3rd article - Installation of signs that “The installation of traffic signs on public roads can only be carried out by the competent authorities for their signalling or with the authorization of these entities”. In 2005 the Law Nº 44 [7], stated in point nº3 of the 4th article that “municipal regulations can only contain provisions (on traffic) which may be signalled in the terms of the Road Traffic Code and complementary legislation, only becoming mandatory when the corresponding signs are placed”. But only in 2018 did the “Framework law on the transfer of competences
to local authorities and to intercity entities” [8] defined in its 21st article - Transport and traffic infrastructures that “Without prejudice to the inter-municipal entities competences, it is the responsibility of the municipal entities to manage all roads in the urban perimeters and their equipment and infrastructures”. Thus, for urban, municipal and regional roads inside the municipality jurisdiction the supervising competent authorities are the city council and assembly.

Unfortunately, there is no law stipulating that municipalities must draft municipal traffic regulations neither how it should be done. In 2012, National Authority for Road Safety [9] released a 8 pages “Guide for the preparation of municipal traffic regulations” to assist municipality that freely planned to prepare a municipal traffic regulation. The guidance, however, was more concerned with the formal (written) definition of the regulation than being a technical support.

This situation has led to a legal vacuum, in which road signage in urban areas are the responsibility of the municipalities, that are not obliged to prepare municipal traffic regulations. The legislation also leaves to the discretion of each municipality the definition of the department responsible for its implementation. Some municipalities have defined municipal traffic commissions, but even their constitution is uneven between municipalities. Of the traffic commission's regulations found online (most constituted after 2018), the commissions ranged from 5 to 20 members, most of whom were politically nominated and without apparent technical knowledges.

Thus, due to legal requirements, local authorities are the managers of road signs (which includes its registration and maintenance). Placing traffic sign has an imposing character, establishes prohibitions, information and warnings and is intended for all public road users. For signage to be legally effective, it must be translated into an administrative act of external effectiveness. Thus, it is mandatory for the municipality to “elaborate and submit drafts of external municipal regulations for approval of the municipal assembly” [10]. The placement of traffic signs in urban areas by any other institution or individual, is not allowed without the municipality’s authorization. To avoid situations of unauthorized signage change, either with replacement or disposal, the municipality must be able to check all the signs implemented, preferably with data of its exact location and pictures of it. This municipal traffic regulation should impose georeferenced registration of all road signs and their maintenance plan. These features, with a strong spatial component, highlights the need to implement municipal road signs management systems, that allow the location and identification of all the relevant elements of road traffic facilities and equipment, validated through deliberations of municipal assemblies.

Nevertheless, a preliminary online survey in 2021 with 207 Portuguese municipalities (67% of the 308 Portuguese municipalities) revealed that only 39% had an approved municipal traffic regulation, only 36% had the locations of traffic signs and 18% the location of road surface marks.

2. Geographic information systems in the management of vertical signs
Because signs are so critical for public safety, having a good sign management system with up-to-date inventory data is an important part of the transport asset management effort. Many municipalities still keep the traditional process of collecting sign data in spreadsheets, making it difficult to preserve data integrity and to use it effectively to maintain an inventory of properly placed, well-functioning signs.

Road sign maintenance requires effective tracking mechanisms to identify sign locations and issues and to be able to fix them within budget constraints. An effective sign management system should address the following features in an integrated manner:

- Inventory: Keep a database of all the signs in the road network under jurisdiction.
- Inspection: Track scheduled inspections for signs;
- Preventive maintenance: Perform work activities to ensure that signs reach their full-service life;

...
• Repair and replacement: Establish a program for repairing or replacing of non-functional signs;
• Reporting and recordkeeping: Maintain records of all maintenance activities.

A Geographic Information System (GIS) can be a valuable tool to improve the municipalities' management competences in an integrated manner. Only an in-depth knowledge of the territory guarantees effective and efficient municipal management. Thus, the control, management and integrated maintenance of road signs are better managed with resources in a GIS environment.

The record in a GIS of all vertical signs in the jurisdictional area of a municipality, allows both technicians and decision-makers, the use of planning, management and visualization tools, of all available information, namely location, conservation status, features and signs types in the territory and identification where they are missing. Thus, it constitutes essential information to support the strategic decisions of the municipalities to achieve and sustain a desired state of good repair over the lifecycle of the assets at minimum practicable cost.

There are world-wide examples of traffic signs management systems with GIS features, largely developed by commercial companies, that generally manage extensive areas and have other features attached like pavement asset management system. The cost of these systems are generally unaffordable for small municipalities in low density areas, that even so continue to have the existing gap in municipal management concerning traffic regulations and road signage, therefor justifying the carried out study and the proposed methodology.

3. Methodology for registration and management of vertical signs
For the registration of road signs, it is necessary to define all the relevant information that characterize the signs, as well as their correct configuration for integration in a relational database. The definition of a good database is the essential part of a GIS. It allows the optimization of data storage associated with the attributes of the different existing entities. For the definition of the relevant information to be collected about road signs, national regulations must be considered. In the present study the consulted INIR normative requirements were: Vertical Signalling - Characteristics [11] and Vertical Signalling - Placement Criteria [12].

As previously mentioned, it was decided to restrict the study to vertical and traffic lights located only in urban areas. In view of the normative requirements, it was decided to define traffic sign sets, rather than single signs, consisting by the support and sign or conjugation of several signs. This assumption allows a single location in the case of sign sets with several signs, facilitating their spatial visualization and optimizing the database. All sign sets were defined as "point" geometric data features, in the European Terrestrial Reference System 1989 (ETRS89-PT-TM06) coordinate system, in accordance with European Reference Frame (EUREF) recommendations and in accordance with the present Portuguese legislation [13].

The preliminary works consisted in the coherent organization of the field data and in the definition and collection of all relevant information on existing signs sets. The characterizing collected information about signs set included: location, type and subtype of sign, material, shape, colour, symbols or alphanumeric characters, photo, intrinsic characteristics of its physical state, sign placement date, information about replacements, type of road, position and sign orientation, among others. Considering the sign support, information was collected on: type of support, material, free height from the pavement/sidewalk level up to the first sign, projected distance from the sign to the roadside, support conservation status (empirical evaluation), obstacles to visualization, perpendicularity of the sign set in relation to the road axis, verticality of the sign set regarding the horizontal plane, type of fixation to the support, type of signs combination in the support, number of
signals supported, and number of supports that have double signage (front and back). As for the characterization of the sign itself, the collected information allows to analyse: number of signs by type and subtype, sign size and sign conservation condition (empirical evaluation).

Once all elements to be collected have been defined, an on-site survey of existing signage in the urban area was carried out, using manual registration on spreadsheets or with data entry software, combined with a Global Navigation Satellite System (GNSS) receiver. Each sign set is assigned a unique identification field, also known as the primary key, which will be used for its identification in all system components (geometric features and attribute tables). From the collected GNSS information, only planimetric data was considered (more accurate), with the sign set height measured using a tape measure.

At office, the collected information was converted into a shapefile format. The shapefile attribute tables were complemented with the collected data, through an open-source Geographic Information System - QGIS®. The GIS also allows the creation of data entry forms, whose fields can be filled in later, with complementary data to be added.

All collected data must then be verified and validated by a qualified technician. The correct implementation of this system allows different spatial analysis and its visualization through thematic maps enhancing data interpretation, decision making, intervention strategies definition and cost-efficient planning.

4. Case study: road sign management system for the village of Belmonte

The suggested methodology was applied to a case study in the urban perimeter of the municipality of Belmonte [14], district of Castelo Branco, Portugal. According to the 2011 Census, the municipality of Belmonte has a population of 6859 inhabitants in an area of 118.76 km², resulting in a density of 57.8 inhabitants/km², considered to be a low population density zone (on the limit of 50 hab./km² criterion for sparsely populated areas, according to EU Regulation No. 1303/2013 [15]). The aim of the case study was a proof of concept of the feasibility of implementing a low-cost GIS for vertical signs and traffic lights management, enhancing the municipality's organization skills concerning financial, human and infrastructural resources, as well as the effective and efficient use of information tools for analysis, control, maintenance and conservation of municipal assets.

4.1. On-site survey data

The data collection about signs set information took place on December 16, 2018, using a Trimble GNSS receiver equipment, model Geo 7x. In addition, the equipment allowed the association of the sign set photo at each location. The survey team had 2 persons that collected the on-site information in 8h (344 sets) and processed it at office throughout 30h (4 days). The used GNSS receiver has TerraSync data entry software incorporated. To obtain a quick features’ location the coordinates were obtained in around 5 minutes with an average accuracy of 1m (considered enough for the survey purpose). In places with higher buildings this apprehension time can take more time due to GNSS signal blockage. Before starting the data collection, a file name, the coordinate system, the geometric and alphanumeric features to be collected had to be defined. Figure 2 shows how the TerraSync software allows georeferencing through different geometric entities. Each sign set entered as a point entity. Field data was then exported to QGIS (figure 2). The cartographic base used was aerial orthophotos (raster data) at a 1:2000 scale, owned by the Municipality of Belmonte.

Table 1 presents the summary of the number of different types of collected sign sets (480 signs at 344 sets).
4.2. Office Work

4.2.1. Data base. The creation of the database in QGIS was carried out through GeoPackages, open format for geospatial information with file extension *.gpkg, independent of the platform, based on open standards, portable and compact for geospatial information transfer. This type of file has the advantage over shapefile format of allowing the storage of vector data, raster data, metadata, alphanumeric data, among other internal database features. This format also allows less storage space, more advanced spatial analysis, as well as faster processing.

![TerraSync working environment](image1)

![344 Belmonte’s georeferenced signs sets locations exported to a QGis project](image2)

**Figure 2.** Left: The TerraSync working environment with the options for the geometric feature selection; Right: The 344 Belmonte’s georeferenced signs sets locations exported to a QGis project.

**Table 1.** Number and sign sets and equipment collected.

| Sign set type and traffic equipment      | Quantities |
|------------------------------------------|------------|
| Danger signs                             | 9          |
| Give-way signs                           | 57         |
| Prohibition signs                        | 94         |
| Combination of signals                   | 6          |
| Mandatory sign                           | 35         |
| Mirrors                                  | 12         |
| Zone signs                               | 5          |
| Information signs                        | 121        |
| Pre-signalling sign                      | 1          |
| Directional signs                        | 86         |
| Additional panels                        | 32         |
| Complementary signs                      | 14         |
| Traffic lights                           | 5          |
| Tourist signs                            | 3          |
| **Total**                                | **480**    |
4.2.2. Geometric data. The geometric data was set as a “point” type, corresponding to the sign set planimetric location at the base of the support. This point shapefile was named “Vertical_signs_BTM” and contains several attributes (fields), namely: primary key (ID_support), type of sign, support height, associated toponym, urban settlement, and parish.

4.2.3. Supplemental alphanumeric data. Three alphanumeric tables were created called: “Sign_Charact”; “Sign_Identi”; and “Compl_Info”.

The table “Sign_Charact” contains information that characterize the sign support. The table “Sign_Identi” characterizes the signs existing in each of the supports (see table 2). It should be noted that the sign identifying code (ID_sign) represents the sign order from the bottom of the support to the top. This order is essential for the correct representation of the sign set.

The table "Compl_Info" refers to complementary information of the sign set, including the inventory date, monitoring date, as well as other information about abnormal situations.

| Field Name            | Description                                           | Widget                        |
|-----------------------|-------------------------------------------------------|-------------------------------|
| ID_support            | Support unique identifier code                        | Sequential number             |
| ID_sign               | Sign unique identifier code                           | Sequential number             |
| Signalling_group      | Identifies the signage group to which the signal belongs | An auxiliary alphanumeric table named "Sign_group" was created with a value relation widget (for example: A - Danger signs; B - Give way signs; C - Prohibition signs) |
| Sign_designation      | Identifies the sign name                              | An auxiliary alphanumeric table was created named "Sign_Designa" with a value relation widget (example: A1a - Right Curve; A1b - Left Curve; ...; B1 - Give way; ...; C1 - Prohibited way; ...) |
| Photo                 | Sign image in SGV format                              | attachment                    |
| Sign_dimension        | Identifies the sign’s size: if it is less than 50cm, between 70 and 90cm, or not applicable | - <50                          |
|                       |                                                       | - 70                          |
|                       |                                                       | - 90                          |
|                       |                                                       | - na                          |
| Conservation_state    | Describes the sign state of conservation (qualitative) | - Good                        |
|                       |                                                       | - Reasonable                  |
|                       |                                                       | - Bad - rusty                 |
|                       |                                                       | - Bad - damaged               |
| Double_sided          | Identifies cases where the sign set is double-sided with the same sign, different signs or not applicable | - Yes, with the same sign     |
|                       |                                                       | - Yes, with different signs   |
|                       |                                                       | - na                          |

4.2.4. Relationships between the geometric layer and the alphanumeric data. Since these systems use relational databases, where the geometric data relates to the alphanumeric tables fields, it was necessary to define the connection fields between different elements of the database. The geometric “points” features that define the planimetric location of the sign set were identified through a field designated “ID_Support”. The connection field of the “Sign_Charact” and “Sign_Identi” tables have the same name (“ID_Support”). In the event that each support has more than one sign, the field “ID_sign” was defined for each sign, allowing the definition of the sign order on the support line. This possibility led to the consideration of a many-to-one relationship between the “Sign_Identi” table and the geometric features of the “Vertical_signs_BTM” layer. In the table “Compl_Info” the connection field with the graphic element was designated as “ID_Comp_Inf” equivalent to the “ID_Support” of the previous tables.
4.2.5. Forms. Using QGIS’ Form Design Functionality to fill forms allows to optimize the data entry process in the attribute tables. Several filling forms have been defined, which allow data insertion in a friendly environment, as well as personalize filling lists with specific values for the attributes (widget). These forms allow a more direct filling in of the attributes associated with the sign set, according to predefined values for them, leading to less input errors and optimizing search queries. It also allows associating the pictures of the sign set surroundings (figure 3).

![Figure 3. Example of a custom filling form.](image)

4.2.6. Symbology. In a next stage, identification symbols of each signage were created in accordance with the “Traffic Signalling Regulation” [6]. However, there are signs that the Belmonte Municipality adapted to its geographic reality (figure 4), being authorized if there is a municipal assembly deliberation approving it. The signals were designed using free software Inkscape version 0.92.3, whose files have the extension *.svg. Figure 4 illustrates an extract of the study area with the sign sets position exemplifying the created symbology.

![Figure 4. Left: Example of a custom sign adapted to the Municipality of Belmonte; Right: Symbology visualization in QGIS project.](image)
5. Results and discussions

From the analysis of the collected data, it was found that in the urban center of the Belmonte village (with an area of 1.58 km²) there are 480 signs, distributed among the 344 supports, of which 327 are in galvanized tube. According to the Traffic Signalling Regulation [6], signs intended for pedestrians must be between 1.8m and 2.2m above the pavement. However, the Vertical Signalling - Placement Criteria (VSPC) normative [12] is more protective, to assure pedestrians move safely in urban settlements, and defines a minimum height of 2.2m, which preventing pedestrian from hitting the signage. In the case of the Belmonte village, 267 units have heights less than 2.2 meters, requiring rectification. The database also allows to evaluate the number of signs by support. The majority (78%) of the 344 supports has a single sign and 4 sets (1%) reach 8 signs in one support, as shown in table 3.

| Number of signs per support | Supports |
|----------------------------|----------|
|                            | N  | %  |
| 1                          | 270| 78%|
| 2                          | 59 | 17%|
| 3                          | 5  | 1% |
| 4                          | 1  | 0% |
| 5                          | 3  | 1% |
| 6                          | 2  | 1% |
| 8                          | 4  | 1% |
| Total                      | 344| 100%|

As an example of the information that can be retrieved from the database, concerning sign type, 94 prohibition signs were identified, of which 28 were of subtype C1 - Prohibited direction. It was also possible to determine that the most common sign dimension is the 70 cm size (either circular or square), with 293 units. It should be noted that 49 units have a size of only 50 cm, used in sign C13 - 50km/h speed limit, whose reading is only noticeable at reduced speeds. An empirical analysis of the conservation state revealed that there are 68 signs without appropriate retroreflection, requiring quick replacement. In general, the observed conservation state was considered reasonable (341) and good (47) (figure 5).

The developed system also allowed to find the existence of 15 sign sets whose visualization is obstructed by several urban elements, such as walls and vegetation. These conditions restrain their main function, transmitting suitable information to drivers and endanger other road users.

In terms of traffic lights, Belmonte village has five S1 - traffic lights (two with circular tricolour signs and three with circular yellow blinking light). All seem to be in a reasonable state of conservation.
6. Conclusions

Road signs are crucial to the road transport system, contributing in a decisive way for a proper traffic circulation. Included in road signage, vertical signs are one of the most relevant groups, whose legibility is essential to anticipate potential risk of accident situations and safer traffic conditions.

Municipalities are responsible for the management of urban territories, through resources management and thoughtful use of urban spaces, to achieve a sustainable development. It is also mandatory for City Councils, as well as their municipal assemblies, to approve municipal regulations for the maximum effectiveness of the municipality’s competences. In the subject of road signage, the municipal regulation must be adapted to its administrative area specificities.

In this context, GIS represent a powerful tool to support decision making by local authorities. They have the capacity to store and manage geographic and alphanumeric information, in an interconnected and structured way. They guarantee conditions for quality management, representing of the existing situation and with the ability to help model future scenarios.

With the suggested low-cost methodology using the GIS, it was possible to evaluate the existing vertical traffic signs, namely specifying their numbers and location, as well as an empirical estimate of their conservation state. One of the most relevant results of the proposed system is the on-the-spot possibility to query the database and quickly obtain results and their location. The system also allows the signage monitoring and an easy updating of the database information.

With the developed system it is possible to carry out studies of urban management, namely for traffic conditions, without the need of on-site work to find out what signs exist in each street. The suggested methodology can also serve as a basis for the establishment of an intervention prioritization.
methodology, assisting with a rapid spatial identification of the signs that need to be intervened. The use of open-source software makes the system cheaper to implement and suitable for smaller municipalities. For low-density areas, with less urban furniture to address, the field data assessment can be carried out quickly by a few local technicians and without the need for in-depth knowledge of advanced management systems.

As weaknesses, the authors highlight the possible delay in collecting and introducing information into the system, as well as the vulnerability to possible human failures. These failures can occur in the introduction of identifications (primary keys), location or description of sign elements, both in the geometric layer and in the alphanumeric tables. Also, in the carried-out study, an empirical methodology was applied to assess the qualitative conservation state of the analysed signage. The authors consider that quantitative methods should be adopted in further improvements, using objective and measurable criteria. These improvements should extend to signs' retro-reflexion evaluations, that was not possible in the present study, despite its relevance to road safety. Most of these evaluations methods already exist, but an extensive research is required to evaluate the ones with best cost-benefit relation possible to include attending budget restrictions.

It is also imperative to adopt measures for quality control of the information contained in the GIS, present and future ones. Municipalities must guarantee the quality and reliability of this basic information, as well as of the results. In addition to possible errors in surveying and recording, there is a high probability of changes, both in the location and in the physical structure of the sign set, which may jeopardize its correct function. These changes can be motivated by: adverse weather conditions, accidents, natural degradation, vandalism, sign upgrading, traffic management changes, among other reasons. The control measures to be adopted must include the periodic (annually) comparison between the existing and registered information; creation of a participation of non-conformity sheet, communicated by police, the municipality's intervention team, or simply by public road users. This procedure has the dual purpose of allowing quick repair/maintenance of damaged element, as well as updating the database. These reports can extend to checking and controlling existing vegetation and any obstacles that avoid the correct sign visualization by drivers.

The record of all interventions in the traffic sign system can also enhance the citizens knowledge about the technical and legal procedures to locate road signage. Records of municipal traffic commissions deliberations, of city council and city assembly approvals, and pictures (of signs and surroundings) and implementation dates can ensure the legality of the signage.

As a final comment, the authors consider it was possible to prove the feasibility of implementing a low-cost system, with a low initial investment in GIS training and through a regular survey of relevant information.

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