

Article

# Mapping Heritage: Geospatial Online Databases of Historic Roads. The Case of the N-340 Roadway Corridor on the Spanish Mediterranean

Mar Loren-Méndez <sup>1,\*</sup>, Daniel Pinzón-Ayala <sup>1</sup>, Rita Ruiz <sup>2</sup> and Roberto Alonso-Jiménez <sup>3</sup>

<sup>1</sup> Departamento de Historia, Teoría y Composición Arquitectónicas, Ciudad, Arquitectura y Patrimonio Contemporáneos, Universidad de Sevilla; 41012 Sevilla, Spain; pinzonayala@hotmail.com

<sup>2</sup> Departamento de Urbanística y Ordenación del Territorio, Universidad de Castilla-La Mancha, 38437 Castile-La Mancha, Spain; Rita.Ruiz@uclm.es

<sup>3</sup> Departamento de Historia, Teoría y Composición Arquitectónicas, Universidad de Sevilla, 41012 Sevilla, Spain; robertofcalonso@gmail.com

\* Correspondence: mar@arqyestudio.com or marloren@us.es; Tel.: +34-670-529-725

Received: 27 January 2018; Accepted: 14 March 2018; Published: 1 April 2018



**Abstract:** The study has developed an online geospatial database for assessing the complexity of roadway heritage, overcoming the limitations of traditional heritage catalogues and databases: the itemization of heritage assets and the rigidity of the database structure. Reflecting the current openness in the field of heritage studies, the research proposes an interdisciplinary approach that reframes heritage databases, both conceptually and technologically. Territorial scale is key for heritage interpretation, the complex characteristics of each type of heritage, and social appropriation. The system is based on an open-source content-management system and framework called ProcessWire, allowing flexibility in the definition of data fields and serving as an internal working tool for research collaboration. Accessibility, flexibility, and ease of use do not preclude rigor: the database works in conjunction with a GIS (Geographic Information System) support system and is complemented by a bibliographical archive. A hierarchical multiscale heritage characterization has been implemented in order to include the different territorial scales and to facilitate the creation of itineraries. Having attained the main goals of conceptual heritage coherence, accessibility, and rigor, the database should strive for broader capacity to integrate GIS information and stimulate public participation, a step toward controlled crowdsourcing and collaborative heritage characterization.

**Keywords:** online heritage databases; geospatial databases; architectural heritage and infrastructure; sustainable heritage and tourism; cultural tourism; historic roadway corridors; Mediterranean cultural heritage; narrative heritage geo-visualization; location-based landscape heritage storytelling; the N-340 Spanish Mediterranean road

## 1. Introduction

### 1.1. Background: Limitations of Heritage Catalogues

The online geospatial heritage database is a product of a research project titled “The N-340 roadway corridor as historic axis on the Andalusian coast: methodologies for heritage characterization and strategies for sustainable regeneration”. The study was aided by a grant from the European Regional Development Fund within the framework of a research program involving heritage experts engaged in spatial analysis in different fields, ranging from civil engineering and geography to architecture and urban planning.

Since 2000, the authors have directed and participated in the compilation of a number of heritage catalogues for master plans in Andalusia. The authors also developed the section on the province of Malaga in the Andalusian Register of Twentieth Century Architecture, which was awarded first prize by the Official Board of Architects of Malaga in the category of architectural promotion and development (2007–2008). The authors' heritage studies on Malaga have been presented and published both nationally and internationally.

It is relevant to point out that in the second half of the last century, legislation for the protection of heritage in Spain led to the integration of heritage management within the urban planning and development process, as contemplated in the first Land Law (*Ley del Suelo*) in 1956 and in the current Spanish Historical Heritage Law of 1985 (*Ley 13/1985, del Patrimonio Histórico Español LPH85*).

The online geospatial heritage database aims to overcome the following main limitations in the design and development of traditional heritage catalogues in general, and heritage databases in particular:

1. The isolated character of assets listed in traditional heritage catalogues. In the context of Spain, heritage catalogues included in urban development plans essentially consist of a collection of item cards displaying the heritage protection level, a photograph, a location map, and basic identification data, sometimes supplemented with historical detail. The format makes it difficult to attain a satisfactory integrated overview of the extent and cohesion of the heritage characteristics the city and territory have to offer.
2. Although assets are generally indicated on a map, their general isolated itemization is worsened by a lack of systematized geographical information on the databases, thus hindering the process of establishing territorial relationships, locating areas of heritage concentration, and elaborating an integrated heritage reading of the study area. In the last decade, geographical information has been produced with specialized GIS software, accessible in most cases, however, only to experts, rather than researchers, institutions, and the general public.
3. The rigidity of heritage databases systemizing cultural heritage in general, and architectural, urban, and archaeological heritage in particular.

In the case of Andalusia in southern Spain, the need to offer a general template for researchers working on the Andalusian cultural heritage database led to the establishment of a set of permanent fields to fill in; researchers have, however, struggled to find the right place to include information relevant to the heritage characteristics of a particular asset, suggesting that these are not user-friendly platforms. For example, the same fields were used to characterize a building—a hotel tower in Marbella—and a new town constructed to colonize potential rural areas.

The limitations of traditional catalogues and databases derive from the historically monumental approach to heritage, where the assessment process focuses on the individual asset without relating it to the environment and/or to other heritage assets, thus reducing the heritage characterization of its values. Although the conceptual field underpinning heritage studies has not ceased to widen in scope since the 1950s at both a semantic and methodological level, traditional heritage catalogues and databases suffer from a certain inertia, impeding the incorporation of key aspects of conceptual transformations, such as the consideration now given to a more extensive spatial context; the complexity and characteristics of each type of heritage; and the essential appropriation and transferal process to society—institutions, experts, and the general public—where IT plays a crucial role in the work of heritage experts.

Heritage characterization of historic roads has given us the ground to offer a critical reflection on such limitations and make a specific proposal that allows us to reframe the heritage database, both conceptually and technologically. The study aims to explore, design, and develop an online geospatial database for assessing the complexity of roadway heritage, transcending the present fragmented approach to its characterization and facilitating the integration of natural, cultural, and historical features into a cohesive form. The study also creates an accessible, user-friendly

tool for raising awareness of this form of heritage among researchers, institutions, and the general public (Figure 1).

The systemization of research results in the database has highlighted the lack of protection given to roadway heritage features along the N-340 on the Andalusian coast and the need to develop specific policy proposals. The online database serves as a work tool for researchers and other agents, while also offering the general public access to heritage information and a form of narrative through the design of its roadway heritage itineraries. Limitations that have arisen in the application and visualization of the geospatial database developed in GIS are also identified.



**Figure 1.** Project homepage: (a) as viewed on a desktop computer (<https://n-340.org/>); and (b) as viewed on a mobile phone (<https://n-340.org/>). Screenshots by the N-340 research team, January 2018.

## 1.2. Current State of the Research Field

This is the first publication to offer a thorough monographic study of an online geospatial heritage database for historic roadways. The results have been partially presented in a general methodological framework developed in the same research project [1]. Systematization and categorization of heritage assets certainly constitute a relevant field within heritage studies. Most heritage catalogues are still based on traditional “heritage cards”, and this explains recent works that focus on a method for analyzing and integrating this paper-format information [2].

The need for an encounter between the complex reality of heritage and ICT (Information and Communications Technology) has been pointed out [3]. There is indeed an emerging field focused

on heritage databases and technology. Although conceptual transformations in heritage assessment have taken place since the second part of the twentieth century, research exploring the potential relationship between the new complexities in heritage assessment is still scarce. Studies have usually developed pragmatic topics, such as standards application [4]. Some publications have focused on web-enabling/online accessibility of heritage catalogues, usually working in specific fields such as architecture [5].

There is now a special interest in the integration of geo-information data into heritage databases through the use of GIS technology: its capacity to relate geographical and alphanumeric information offers the tools to overcome the traditional isolated character of assets in databases. Some studies focus on exploiting the technical capacities of this technology; for instance, in the systematic management of large volumes of heritage data [6], to create accurate digital representations of certain assets [7], or to combine GIS with other technologies, such as virtual and augmented reality (VR and AR) in heritage characterization [8].

In Andalusia, the use of GIS for heritage databases has been explored specifically in the field of archaeology [9] and in the development of an information system for highly relevant monuments, such as the Alhambra in Granada [10,11]. At a national level, the Spanish Cultural Heritage Institute (IPCE, Instituto de Patrimonio Cultural de España) has developed a research project on the use of GIS in heritage conservation [12].

However, although programs such as ArcGis are developing online versions, most projects exploring the use of GIS for heritage databases cannot be consulted online and require specific programs, limiting access to results to the research team or the institution. This lack of access is a problem that has been pointed out by certain authors [13]. Online accessibility and visualization of heritage characterization with GIS has therefore become an emerging topic. However, publications that focus on online visualization of heritage characterization produced with GIS are still scarce [14].

Arches Heritage Inventory and Management System (ARCHES) has dealt directly with the main objective of combining a heritage database and supporting effective heritage place management and online accessibility, having developed open-source geospatial software. The product is not, per se, a heritage database, but a software platform for the creation and management of different inventories all over the world. There are studies that offer an overview of the system [15] and case studies that use the platform to develop a specific digital heritage inventory, detailing the field data included and the heritage resources considered [16].

Regarding the specific case of linear transport infrastructure, there are several research studies in which digital tools and GIS techniques have been implemented to collect heritage and spatial information, and to provide powerful technical support for conservation programs. This is the case of the strategies developed for the Grand Canal [17], heritage railways [18], historic trails such as the Qhapac Ñan [19], and greenways [20].

Previous studies have focused on developing heritage databases that offer itineraries and routes. Walking tours in historic cities are already considered a general product of cultural tourism, and this means that there is an emerging field in its technical support [21]. In contrast, itineraries related to roadways, historic paths, and railways are still scarce: some studies have suggested a framework for characterizing historical transport resources, attractions, and attributes [22,23]. However, specific literature dealing with modern roadway corridors is rare [24,25]. In this respect, the present study also explores how to exploit an online heritage database to develop itineraries, opening up the heritage experience to the general public, a crucial factor in the appropriation process.

## **2. System Design: Consistency in the Conceptual Methodology Applied to the Characterization of Heritage**

The research focuses on the section of the N-340 roadway along the coastline known as the Costa del Sol. Specifically, it characterizes the historic roadway heritage present in the western section of the

N-340 between the coastal cities of Malaga (province of Malaga) and Algeciras (province of Cadiz), a distance of 160 km (Figure 2).

The screenshot displays the 'ÁMBITO' (Scope) page of the N-340 project website. At the top, a dark navigation bar contains the text 'N-340', 'PROYECTO', 'PARTICIPA', and 'CONTACTO'. Below this is a wide banner image showing a coastal scene with a stone tower and the sea. The main heading 'ÁMBITO' is centered, with a sub-heading 'Inicio / Proyecto / Ámbito'. A paragraph of text describes the project's extent: 'El corredor de la N-340 desde el Río Palmones, entre los términos municipales de Algeciras y Los Barrios, a su paso por los municipios de La Línea de la Concepción, San Roque, Manilva, Casares, Estepona, Marbella, Mijas, Fuengirola, Benalmádena, Torremolinos, Málaga, hasta El Peñón del Cuervo.' Below the text are three tabs: 'PRESENTACIÓN', 'ÁMBITO', and 'EQUIPO'. The 'ÁMBITO' tab is active, showing a map of the study area. The map highlights the historic road path in red and the project area in semitransparent orange. A legend at the bottom left of the map area identifies the red line as 'N-340 carretera histórica' and the orange area as 'Ámbito del proyecto'. The footer of the page features logos for the Spanish Ministry of Industry, Trade and Tourism, the University of Malaga, the Andalusian Government, and the European Union.

**Figure 2.** Area of study. Screenshot by the N-340 research team, January 2018 (<https://n-340.org/proyecto/ambito/>). The historic path of the N-340 roadway is marked in red. The area of study is shaded in semitransparent orange. A corresponding map created in GIS software is available for download in PDF.

The online geospatial database was developed within the framework of a general methodology for the heritage characterization of historic roadways [1]. The following aspects of its design and development are highlighted: an interdisciplinary approach to roadway heritage is proposed that transcends the current fragmented approach to its characterization, enabling the integration of natural, cultural, and historical features into a cohesive form. The database thus needs to be:

- Sufficiently flexible to include all the different layers of heritage, while ensuring utmost rigor.
- A user-friendly work tool, while remaining coherent within the different fields of expertise involved.

The project is also committed to the present role that society plays in the appropriation of heritage characterization. Easy access to the heritage database by the general public is key, as an effective strategy to raise public awareness.

In applying an integrated heritage approach to the methodology, roadways are interpreted within the framework of the openness that currently characterizes heritage studies. Geographical data became critical in facilitating the inclusion of different territorial scales considered in relation to the historic roadway.

### 2.1. Flexibility of the System: ProcessWire

The database overlays roadway heritage features that have traditionally been identified in isolation by architects, civil engineers, geographers, and urban planners working separately. It includes heterogeneous heritage items such as natural and rural assets, technical and infrastructural elements of the road, and architectural and urban features. The system is based on an open-source content-management system (CMS) and framework called ProcessWire, which allows for greater flexibility in the definition of data fields and offsets the need to work within a predetermined data-field structure (Figure 3). Therefore, the system does not place any restrictions on content or design, and facilitates multiple search criteria and interpretations of complex data [1] (p. 494).

The creator and lead developer of ProcessWire, Ryan Cramer, explains, “ProcessWire is designed to have an approachable simplicity that is retained regardless of scale. Simplicity often implies reduced capability, and this is not the case with ProcessWire. From the surface, there is very little complexity and the application requires no training. But open the hood, and you have a lot of horsepower at your disposal for just about any content need. The goal is jQuery or Google-like simplicity (a simple interface to powerful engineering). Regardless of scale, the inherent simplicity and joy in using the interface and CMS API remains consistent, predictable, and capable” [26].

In ProcessWire, each page is made up of a series of fields, i.e., containers, into which you input data (text, numbers, addresses, coordinates, files, etc.) or from which you select data (dropdowns, checkboxes, references to other pages, etc.). All fields in ProcessWire are custom fields and can accommodate unique data needs. ProcessWire makes no assumptions about the kind of data you want to store in the system or the way that you want to structure and lay out your website. This is a major differentiating feature of the system, as it does not limit the choices to a set of predetermined fields (such as “title”, “body”, and “images”), as commonly found in popular CMS such as WordPress and Joomla. This unique flexibility enables a tailored user interface and maintains a consistent presentation, as each field has its own purpose and function, while opening up the possibility of complex relational data manipulation.

The team has worked on defining fields that characterize heritage assets, applying an interdisciplinary conceptual approach to what actually constitutes roadway heritage. Specific fields define, for instance, the “relation to the road” or its “level of accessibility”. Fields commonly found in traditional heritage catalogues, such as “summary”, “historical period”, and “historical descriptions” of relevant publications and official documents, refer to the construction and transformation of the road and its corridor: these historical periods have been further defined for the purposes of this research. General identification data includes “name” (including former or alternative names), “contact information”, “typology”, and “intervening agents”. Heritage data such as “level of protection and conservation” have been specifically included at a local, regional, national, and European level. This is completed with the “current state” of the asset, to allow easy identification of the most urgent conservation work required. A feature image presents the item, complemented with a series of photos and plans, and any relevant historical documentation.

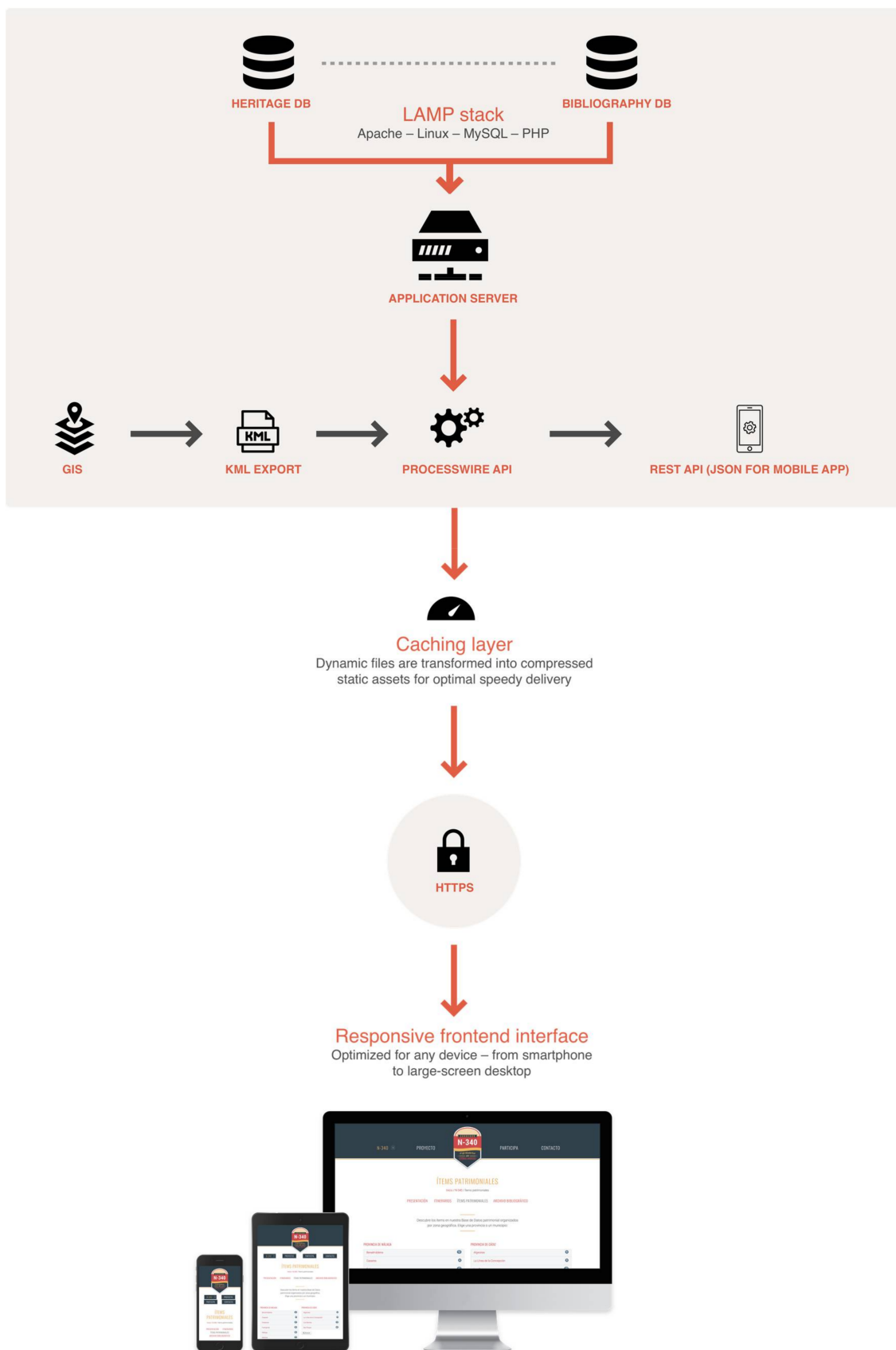


Figure 3. System design.

The relationship of each item to the surrounding territory, the roadway itself, and other heritage items is critical for an overall reading and integrated heritage assessment of the historic corridor. As developed in the following section, each asset is presented with a Google Map interface for visual location, as well as geographical information produced and imported from GIS.

Finally, bibliographical references are also included for every heritage asset. As explained in the following section, this is not an isolated compilation, but an active part of an accessible bibliographical archive.

### *2.2. A Secondary Database: A Specialized and Accessible Bibliographical Archive*

In order to offer rigorous information to experts in the field, the heritage database is complemented by a “bibliographical archive”, a database that is also based on ProcessWire. This archive aims to become a reference for studies on historic roadways in general, and on the N-340 road in particular (Figure 4). The interdisciplinary heritage approach is also reflected in the bibliographical database, with contributions from the various relevant disciplines. It includes all types of publications, cartographies, unpublished research, and reports in relationship to the historical, geographical, architectural, social, or economic context. Bibliographical data is first introduced into the Mendeley reference manager, and then exported to the database. In order to allow constant updating of the archive, the system also allows the inclusion of new bibliographical references; likewise, new heritage items can be added anytime.

The two databases are linked: every heritage asset references its corresponding bibliographic information, including complete documents (if legally available). Like the main heritage database, the bibliographical archive allows all the information to be shared by researchers on the project and cements the commitment to public access in real time. Certain fields are reserved for internal use, for example, PDFs of relevant articles as bibliographical references, historical archives with restricted usage rights, observations, pending tasks, or proposals for heritage protection.

### *2.3. Usability of the System: Instant Public Access to a Working Tool for Research Collaboration*

Researchers can input data through a friendly interface: the database not only facilitates the systemization of results, but also serves as an internal working tool for collaboration (Figure 5). The application is intuitive enough to require little to no training; when researchers are editing a page, the interface is streamlined to focus on the task at hand.

Researchers of different ages, fields, and universities work directly on the system, avoiding a scenario where team members elaborate on the information outside the system and a computer expert or webmaster uploads it afterwards. In our case, researchers are literally working simultaneously within this system, each from his or her own computer. They are able to visualize the work of others and to assure a constant dialogue. A granular system of permissions has allowed us to assign roles to the different members of the team. The ease of use turns the data-entry process from a solitary chore that typically concludes an investigation to a collaborative process that can be viewed in real time. It also allows sharing of results with the public and institutions in real time, avoiding the classic delay in data visualization and obsolescence characteristic of heritage databases in general. There is no need to wait for completion before publication, given the flexibility of the database that allows constant updating and uploading of individual assets by multiple agents.

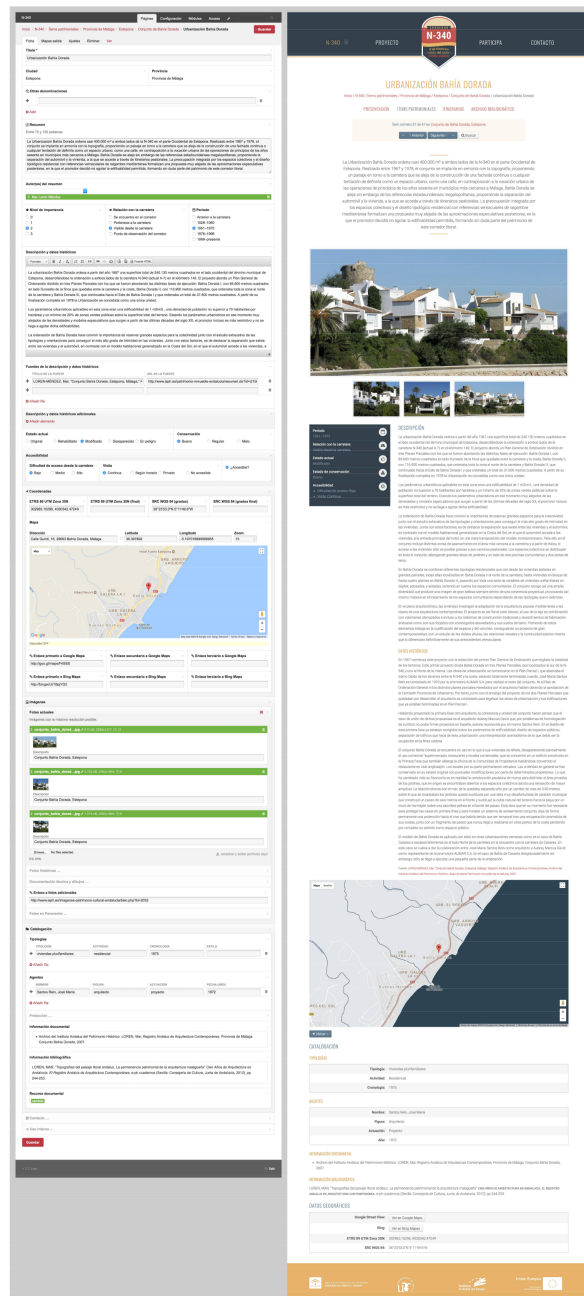


The screenshot shows a web-based form for entering bibliographic data. The interface is in Spanish and includes a navigation menu at the top with options like 'Páginas', 'Configuración', 'Módulos', and 'Acceso'. The breadcrumb trail indicates the current record is a book chapter in a bibliography database. The form fields are as follows:

- Título \***: Documenting, cataloguing and protecting the architecture of the 20th Century: the research process, the institutional commitment, the educational transference
- Título secundario**: Responsibilities and Opportunities in Architectural Conservation: Theory, Educat
- Título en idioma original**: (Empty)
- Número de referencia**: (Empty)
- Año de publicación**: 2008
- Autores primarios**: Loren Méndez, Mar
- Autores secundarios**: (Empty)
- Signatura original**: (Empty)
- Fuente**: (Empty)
- Fondo**: (Empty)
- Volumen (libro) / N° (revista)**: II
- Número de plano**: (Empty)
- Escala (plano)**: (Empty)
- Página inicial**: 15
- Página final**: 30
- Palabras claves**: (Empty)
- Resumen**: (Empty)
- Número de edición**: (Empty)
- ISSN / ISBN**: 978-9957-8602-7-1
- Enlace**: /
- Idioma**: Inglés (selected), Español, Italiano, Francés
- Editorial**: CSAAR. Center for the Study of Architecture in the Arab Region
- Lugar de publicación**: Amman, Jordania
- Notas ...**: (Empty)
- Uso interno ...**: (Empty)

At the bottom of the form is a 'Guardar' (Save) button. The footer of the page shows 'v. 2.7.3 dev' and a 'Salir' (Logout) button.

**Figure 4.** Bibliography database. Customized interface for researchers. Back-end view of the book chapter entitled “Documenting, cataloguing and protecting the architecture of the 20th Century: the research process, the institutional commitment, the educational transference”. Screenshot by the N-340 research team, January 2018.



**Figure 5.** Back-end and front-end views of a heritage item. (Left) Heritage database: customized interface for researchers. Back-end view of the heritage asset of the corridor entitled “Urbanización Bahía Dorada”. (Right) Heritage database: interface for users. Front-end view of the same heritage asset (<https://n-340.org/patrimonio/items-patrimoniales/malaga/estepona/conjunto-de-bahia-dorada/conjunto-bahia-dorada/>). Screenshots by the N-340 research team, January 2018.

The back-end system also allows researchers to build their own multicriteria search engines (Figure 6). It allows not only easy location of the heritage items they are working on, but also data comparison.

Finally, the database also reduces the reliance on third-party services and tools such as shared Dropbox folders, Excel tables, or project management software. Since it is a web app, users do not need to download and install a database program onto their computers.

TÍTULO	FOTOS ACTUALES	RESUMEN	PERIODO	CIUDAD
Camping Marbella 191		El antiguo camping Marbella 191 es un claro ejemplo de la variedad turística que se recoge en torno al corredor de la N-340. En este caso está enfocado a uno más asequible, con una oferta de apartamentos, formalizado en un edificio aterrazado, y otra zona libre para acampar. Su ubicación a los pies de la carretera se denota con el propio nombre del camping que toma el punto kilométrico en el que se sitúa y que trasladó al diseño de la portada de entrada, hoy desaparecida. La estrecha franja de terreno existente entre la N-340 y la playa es aprovechada por el camping con una edificación que se adapta a la pendiente y diversas zonas para acampar a diferentes cotas que le otorgaba gran singularidad.	1951-1975	Marbella
Poste del Cable		Frente a la conocida playa del Cable, en el término municipal de Marbella, se mantiene esta infraestructura única, testigo de los restos de la estación de descarga del cargadero marítimo que en los años cincuenta permitió trasladar minerales desde el término municipal de Ojén hasta la costa, mediante un tranvía aéreo que llegaba directamente a los barcos de transporte en zonas con calado suficiente. Para realizar el recorrido, esta instalación se apoyaba en cuatro castilletes, requiriéndose de dos de ellos para cruzar la N-340 a una altura suficiente.	1951-1975	Marbella

**Figure 6.** Custom multicriteria search engine. “Lister Pro”, a ProcessWire premium module, enables researchers to build their own personalized search engines. Any field present in the heritage database can be used, enabling complex searches and precise results, which can also be exported to an Excel-compatible format for further data analysis. In this example, a researcher found two results when searching for items in the city of Marbella built during the period 1951–1975 and in a poor state of conservation. Screenshot by the N-340 research team, January 2018.

### 3. Geospatial Heritage Characterization

#### 3.1. Producing Geo-Information in the Heritage Database: The Different Scales: Heritage Item, Sequence, and Itineraries

The heritage data of a historic roadway corridor is not concentrated, but dispersed across the territory; it does not correspond to a specific historic city or a historic site. In this case, the corridor runs through 12 municipalities in two provinces. Three of them are in the province of Cadiz: Los Barrios, La Linea de la Concepcion, and San Roque. The others are located in the province of Malaga: Manilva, Casares, Estepona, Marbella, Mijas, Fuengirola, Benalmadena, Torremolinos, and Malaga.

The heritage database must contemplate such geographical complexity to ensure an integrated interpretation of the historic roadway corridor. A hierarchical multiscale heritage characterization has thus been implemented. When logging into the back end, researchers are presented with a hierarchical tree structure consisting of pages emanating from the website homepage (Figure 7). The back-end structure thus reflects the front-end page organization, and proves to be instantly familiar to researchers working on the project.



**Figure 7.** Tree structure. ProcessWire’s tree structure enables intuitive, logical content organization. This screenshot shows how the heritage database branch entitled “Ítems Patrimoniales” (number 1 in image) is structured: first by province (number 2), then by municipality (number 3), then by item or group of items (number 4). In this example, a researcher is accessing the heritage item named “Río Manilva”, located in the Manilva municipality, in Malaga province. Screenshot by the N-340 research team, January 2018.

The heritage database item branch (the “items patrimoniales”) in the screenshot is organized geographically, first by province, then by municipality, and finally by heritage item. This hierarchical organization offers a logical and intuitive structure that allows researchers to quickly locate the item that they need to work on, avoiding abstract references such as ID numbers. It is also coherent with the proposed conceptual approach to heritage, enabling the creation of a group of items that form a sequence—a concept that was developed in the framework of the project: “By applying an integrated approach, heritage sequences with their own historical and geographical rationale can be identified. These sections of road contain high concentrations of heritage assets due to a combination of factors, including geographical conditions, existing features of the area prior to road construction, road infrastructure, and the waves of transformation that this has brought about” [1] (p. 495).

The page structure follows a geographical hierarchy, facilitating the task of retrieving the coordinates for each underlying branch. Using ProcessWire’s simple yet powerful API (Application Programming Interface), we simply need to loop through the “children” of the current page (a province, municipality, or sequence) and retrieve the coordinates (Figure 8).

```

<?php // Loop through all children of current page:
foreach ($page->children as $child) {
    // Retrieve latitude from field named "map":
    echo $child->map->lat;
    // Retrieve longitude:
    echo $child->map->lng;
}
?>

```

**Figure 8.** Simplified PHP (Hypertext Preprocessor) code used to retrieve coordinates for a group of items in a branch below (e.g., items in a municipality or in a sequence). Screenshot by the N-340 research team, January 2018.

Any given page may cross-reference another in a one-to-one or one-to-many relationship. This gives the database the ability to function like a relational database on top of a CMS. The researcher (or the website developer), rather than the software, can define what these relationships are. A case in point is the creation of itineraries: from the user interface, different assets from the page tree can be selected, one by one, to create a customized itinerary (Figures 9 and 10).

The screenshot displays a web interface for managing an itinerary. At the top, a section titled "Destacados" (Highlights) contains a list of eight items, each with a plus icon and a trash icon. Below this is a "cancelar" button. The main section is titled "Ítems patrimoniales 2" (Heritage items 2) and shows a hierarchical tree view of items. The tree starts with "Provincia de Málaga 9" and "Provincia de Cádiz 4". Under "Provincia de Cádiz", there are "Algeciras 1", "La Línea de la Concepción 2", and "Los Barrios 2". Under "Los Barrios", there is "San Roque 10". Under "San Roque", there are "Secuencia de Torreguadiaro 6", "Conjunto desembocadura del río Guadiaro 5", "Club de Golf Sotogrande", "Estuario río Guadiaro", "Fondos marinos estuario del río Guadiaro", "Puente de San Enrique", and "Puerto Deportivo Sotogrande" (which has a "seleccionar" button). Other items in the tree include "Ríos Guadiaro y Hozgarganta", "Secuencia del río Guadiaro 6", "Secuencia San Roque - Guadiaro 4", "Conjunto sistema de defensa contemporáneo de San Roque 19", "Conjunto de Guadalquivir 14", "Fondeadero arroyo de los Patos", "Parque fluvial río Guadarranque", and "Conjunto de Carteia 5".

**Figure 9.** Designing an itinerary. Building an itinerary is a simple matter of selecting pages from the tree. This screenshot of the back end shows how a researcher would add an item called “Puerto Deportivo Sotogrande” to the highlights of the first itinerary. An item can be removed by clicking on the trash icon, and reordered by dragging and dropping to the desired position. Screenshot by the N-340 research team, January 2018.

After adding this item, any of its fields can be retrieved through ProcessWire's API and shown on the front end. Changing the order is a simple drag-and-drop operation. Deleting an asset deemed no longer relevant is just a click away.

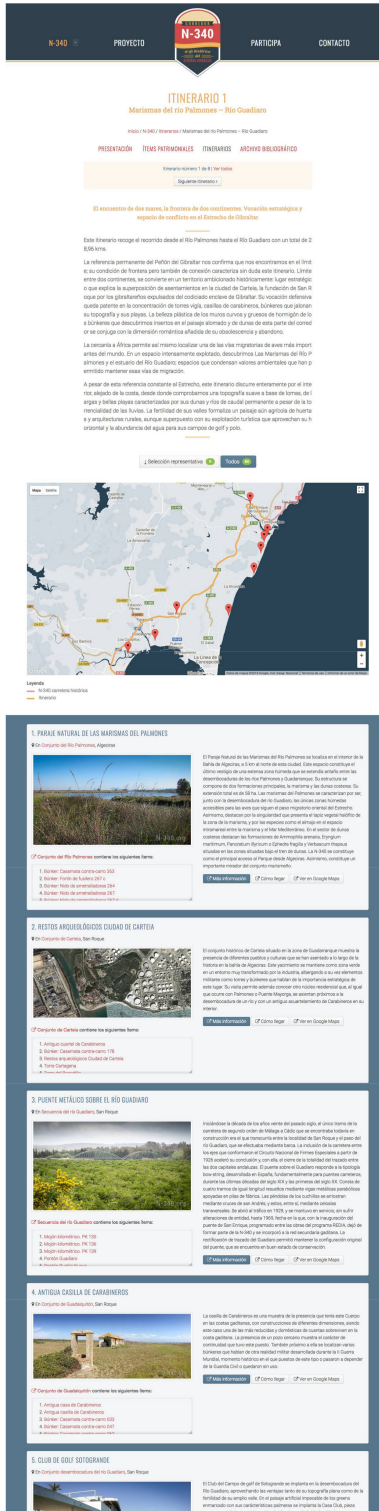
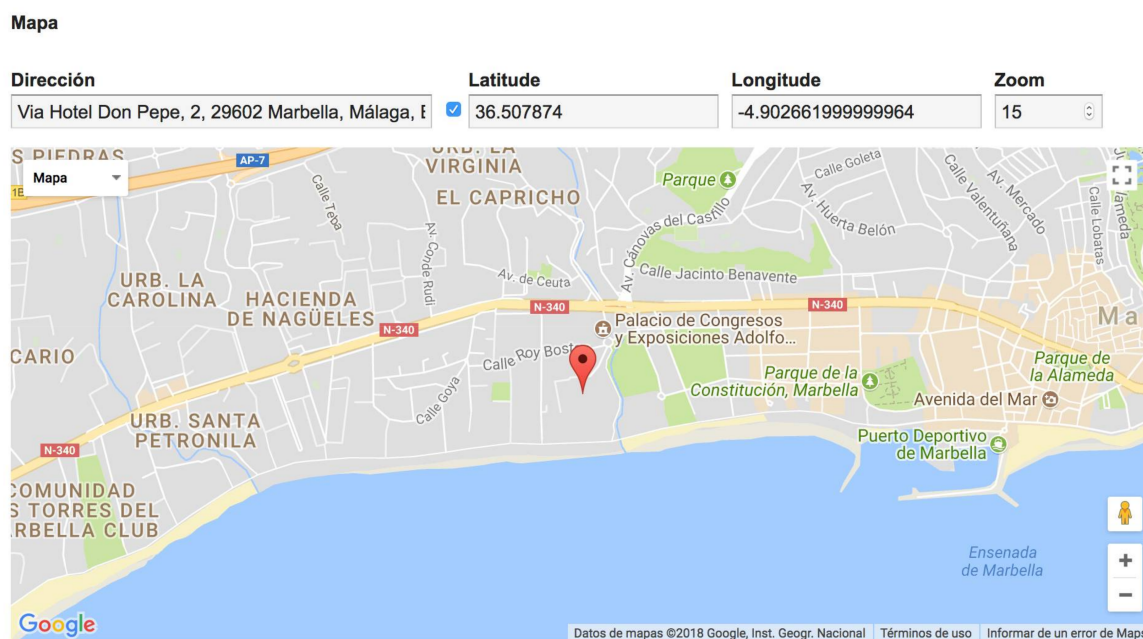


Figure 10. Itinerary 1: Marismas Río Palmones—Río Guadiaro (Marshes of Palmones River—Guadiaro River). “The encounter of two seas, the frontier of two continents. Strategic vocation and space conflict in the Strait of Gibraltar”. The nine representative items along the N-340 road are shown on a Google map and summarized below.

### 3.2. Geo-Accessibility: The Use of Google Maps in Conjunction with GIS

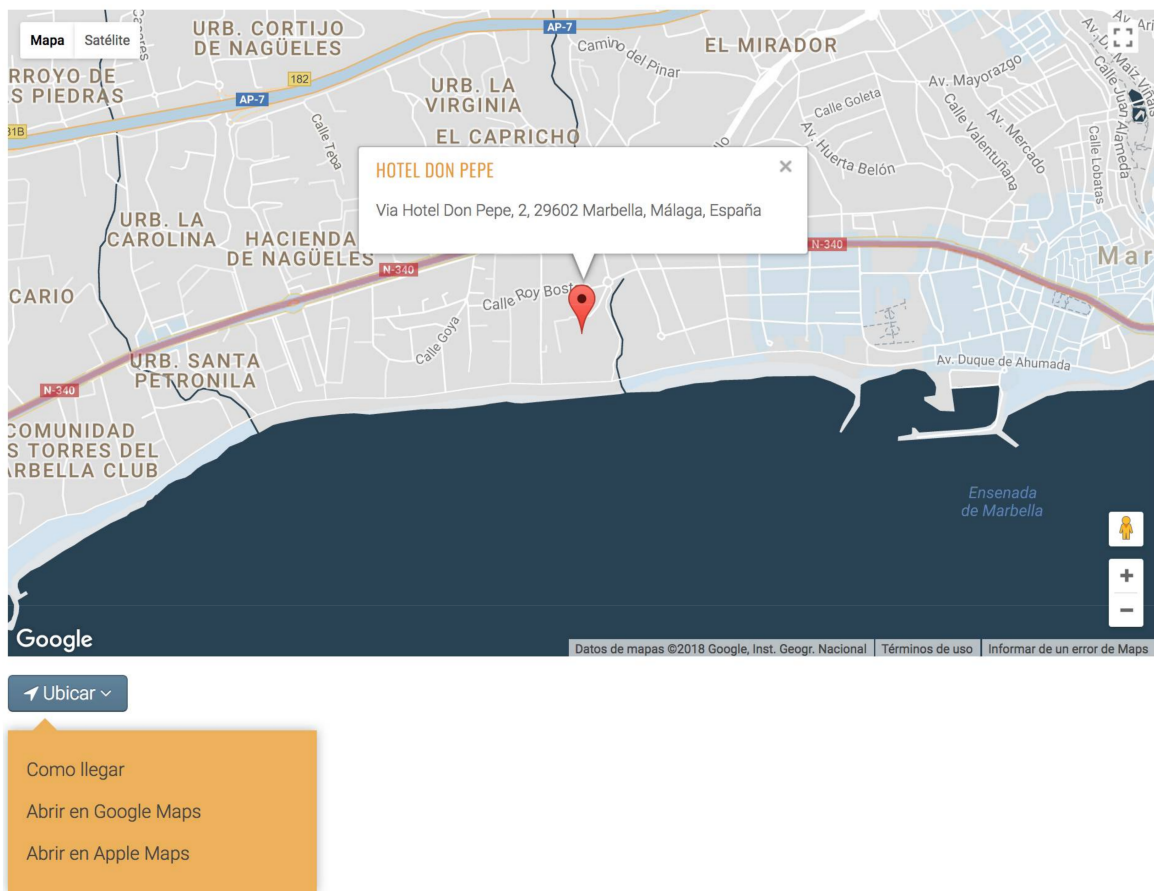
ProcessWire includes a special field type for displaying a Google Map in the back end (Figure 11). It allows researchers to enter an address or location name, which is automatically geocoded to latitude/longitude using the Google Maps API. Reverse geocoding is also possible by entering the latitude/longitude in a Google Maps-compatible format. Researchers can also choose the zoom level, drag the map around, and adjust the pin's location if necessary.



**Figure 11.** Locating an item in the back end. ProcessWire’s “Map Marker (Google Maps)” module enables researchers to enter latitude and longitude (or a street address) to quickly locate the item they are working on. Geocoding and reverse geocoding are supported through the Google Maps API. Screenshot by the N-340 research team, January 2018.

The interface proves familiar to anyone who has used Google Maps, and allows researchers to easily locate and map the items they are working on. The workflow is not interrupted: they do not have to switch to another program to view the location. This has been critical in order to avoid dependence on specialized software by researchers, the general public, and institutions [27] (Meyer and others 2007).

On the front end, the corresponding map for the specific item is shown and styled using the Google Maps JavaScript API in relation to the historic path of the N-340 roadway, which does not necessarily follow the current route as shown on Google Maps. Clicking on the pin shows the geocoded address; a button below reveals various options to access the location and directions: (a) to get the direction to get there, (b) to go to Google Maps, and (c) to go to Apple Maps, allowing visitors to quickly find their way. Street View and Bing Maps are also available (Figure 12).



**Figure 12.** Locating an item on a custom Google Map. Locating “Hotel Don Pepe” on the front end (<https://n-340.org/patrimonio/items-patrimoniales/malaga/marbella/hotel-don-pepe/>). Screenshot by the N-340 research team, January 2018.

In order to complement Google Maps with rigorous geo-characterization, GIS technology was used, specifically QGIS, QGIS, and ArcGIS. This project has explored how to ensure data portability, providing links between spatial GIS data and detailed descriptions of heritage assets offered in the heritage database.

Three phases in the work process can be identified. In the first phase, official heritage geo-data provided by international, national, and regional institutions in WMS and Shape file formats was transferred and integrated into the heritage characterization of the corridor. A table displaying data sources has been published [1] (p. 497).

In the second phase, the heritage findings derived from intense fieldwork, bibliographical searches, and local heritage catalogues that are not in GIS were included.

In the third phase, the research team worked on GIS and the heritage database at the same time, shared the findings, and created a dialogue and real collaboration between GIS and ProcessWire. This means that every item is identified by two coordinates: the SRC WGS 84 used by Google Maps and the official European Terrestrial Reference System 1989 coordinates ETRS 89 UTM zone 30N used in GIS.

The GIS geospatial data files are exported from ArcGIS, including coordinates of heritage assets, alignment of the original historical road, and proposed itineraries. They are converted to KML format and then transferred to Google Maps’ universal mapping services. Together with this importation process, in the front end each item offers two coordinate fields, showing both the SRC WGS 84 and ETRS 89 UTM zone 30N.



Since items are grouped according to various geographical scales—from the widest area, encompassing provinces, down to municipalities, then items and sequences—it was important to show the corresponding items for each layer on a Google Map. The screenshot in Figure 13 shows the result of such an operation for the sequence named “Conjunto Colonia Agrícola San Pedro Alcántara” (<https://n-340.org/patrimonio/items-patrimoniales/malaga/marbella/conjunto-colonia-agricola-san-pedro-de-alcantara/>), composed of six items in the historic agricultural colony of San Pedro Alcántara.



**Figure 13.** Viewing a sequence/group of items. “Conjuntos” and “Secuencias” are groups of items that can be viewed together on a single Google Map. This screenshot shows the six items that make up the “Colonia Agrícola San Pedro Alcántara” (<https://n-340.org/patrimonio/items-patrimoniales/malaga/marbella/conjunto-colonia-agricola-san-pedro-de-alcantara/>). Screenshot by the N-340 research team, January 2018.

## 4. Results

The experimental results following the implementation of the first heritage database for historic roadway corridors are outlined below.

### 4.1. An Online Geospatial Heritage Database

A total of 333 heritage assets have been identified and characterized. The interdisciplinary approach to heritage characterization has resulted in an integration of heritage values of different natures that were traditionally assessed separately as roadways heritage. They include architectural and urban assets (housing, industrial complexes and buildings, military and defensive constructions, water deposits, aqueducts, cinemas, hotels, schools, hospitals, markets, churches, cemeteries, transportation, archaeological remains, and historic city centers); technical assets of the road infrastructure (bridges, road markings, road signs, whole road sections); gardens and parks; rural assets; and natural assets.

This heritage database pays special attention to heritage characteristics, defining specific fields that characterize the heritage of historic roadways. They can be searched by keyword, location, and historical period. Users can also browse items by province or municipality, sort them

geographically or by title, and filter them by sequence. Forty-one sequences have been identified. Users can always visualize each heritage asset in relation to other assets in the sequence.

The geographical location in relation to the historical roadway is always provided, offering consistent visualization of heritage assets in relation to other items present in the same municipality, in the context of a heritage sequence and individually.

#### 4.2. Bibliographical Archive

The online bibliographical archive constitutes an innovative resource, and its design can be applied to other projects. This archive is integrated with the main heritage database: the bibliographical references of each asset is linked with the bibliographical archive. Regarding the specific field of roadways heritage, this archive is becoming a reference for studies on historic roadways in general, and on the N-340 road in particular.

When accessing the bibliographical archive, users know at first glance what type of information can be found: the 469 documents are classified into 17 types. For example, with one click, the user can quickly access the list of 132 articles or the 100 hitherto unpublished technical projects.

Contents range from published material such as articles, books, and proceedings to graphic documentation such as maps to official and legal documents such as public reports and master plans to research information such as projects and PhD theses.

#### 4.3. The Development of the Itineraries

The historic roadway is divided into eight itineraries, each displaying the rich variety of heritage present along the roadway corridor. Individual itineraries cover between 25 and 35 km and include the heritage items present in the relevant section of the road. Eight to 10 items are selected on the basis of a transdisciplinary approach, revealing the heritage complexity of the historic roadway corridor.

In contrast with online tools such as Google My Maps, building an itinerary in this system can be done in a matter of seconds. You pick and choose from a predefined list of places organized geographically, like adding items to a shopping cart. After saving your itinerary, you are presented with a list that includes not only a title, location, summary, and photograph, but whatever information you deem relevant. Since each item is pulled from the heritage database, you can customize the itinerary's presentation: it can range from a simple, succinct list of items for quick reference to a detailed, personalized itinerary based on the needs of a particular set of users. It is thus much more intuitive, thorough, and customizable. The fundamental difference from tools such as Google My Maps is that each item is pulled from the heritage database. When you select an item to add to an itinerary, you bring along all of its data (geographical, descriptive, bibliographical, historical, etc.) and relationships to other items (location, category, etc.).

This heritage database follows a historic road, part of which no longer exists as such or has been radically transformed. As has been explained in a previous article (Loren-Méndez et al., 2016), rigorous and intensive work has been done to identify and locate the original road. The itineraries are able to follow the original road, bypassing the indications of Google Maps to follow the quickest route, i.e., the current highway that partially substitutes for the original road.

#### 4.4. An Intuitive, Real-Time Collaborative Tool for Researchers

The proposed system has succeeded in converting an online heritage database into a collaborative platform for researchers. It also enables constant updating of research and publication of findings in real time.

### 5. Discussion

The online system of integrated heritage has overcome many of the limitations associated with traditional heritage catalogues and databases: the itemization of heritage assets in isolated format;

the lack of geographical information, hindering the establishment of territorial relationships; and the rigidity of the database structure.

From a conceptual point of view, the online geospatial heritage database reflects transformations that have taken place in the field of heritage studies, where territorial scale is key for heritage interpretation and characterization, the complexity and singularity of each type of heritage is accounted for, and public access and awareness is considered a social responsibility. Technology is not just instrumental; it must also be inserted into a contemporary reading of what comprises heritage today. This would help to refine how it should be characterized and open up the process to the whole of society.

The conceptual and experimental results can be applied to other types of heritage. With its associated bibliographical database and development in conjunction with the GIS system, the online geospatial heritage database is based on a system sufficiently flexible to allow adaptation to other types of heritage.

Finally, accessibility, flexibility, and ease of use do not preclude rigor. Both the main online geospatial database and the bibliographical archive are permanently open to new entries and any item can easily be updated. Even itineraries are not designed as final products; they can incorporate new items that extend the narrative of the itinerary or eliminate others. New itineraries can also be created and published in a matter of minutes. All of these operations have proved sufficiently intuitive to be executed by users with no previous technical training.

Having attained the main goals of conceptual heritage coherence, accessibility, and rigor, the database should strive for broader capacity to integrate and visualize GIS information, minimizing manual information transfer. For instance, it might be interesting to be able to draw areas on a map in the back end, or to visualize different GIS layers in the front end.

Promoting easier user feedback and participation is also an area of interest. For example, users/visitors could let us know directly, through a form on the page corresponding to a specific asset, if it is being endangered, how it has evolved since our last physical site visit, or if visitor hours have changed. Taking this a step further toward controlled crowdsourcing, users could also write reviews and rate each item according to a set of preestablished criteria.

**Acknowledgments:** The research was made possible thanks to the Ministry of Public Works and Transportation (Consejería de Obras Públicas y Transportes) of the Andalusian government (Junta de Andalucía). We would like to thank the project managers, Ester Lineros and Rosario Rey, and the project director, Paloma Pineda. We would especially like to thank Jacques Maes, the webmaster behind the online heritage database; his constant support and commitment have been crucial to the research and the article. We would also wish to thank Corinne Stewart for her effort, excellence, and commitment in the final editing processes.

**Author Contributions:** Mar Loren-Méndez directed the research project, participated in the conceptual design of the heritage database, worked on the heritage characterization of the items, and defined the itineraries and sequences. She also outlined the paper manuscript. Daniel Pinzón-Ayala identified and located the historic roadway, coordinated data transfer, worked on the heritage characterization of the items, and coordinated the bibliographical archive. Rita Ruiz carried out background work and worked on the heritage characterization of the items. Roberto Alonso-Jiménez worked on the current state of the research field, specifically on heritage databases and technology. All authors approved the paper manuscript.

**Conflicts of Interest:** The authors declare no conflicts of interest.

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