

# Advanced User Interface for a Geospatial Data Integration Platform

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**Abstract**—Various solutions for dynamic, service-level integration of geospatial data have been developed in the EU-funded Geospatially Enabled Ecosystem for Europe (GeoE3) project. The GeoE3 geodata integration platform is a cloud-based service providing single point access to the thematic content offered by the project. In particular, the project has focused on on-the-fly cross-border integration of datasets originating from legacy country-level services. Access to the platform is based on the Open Geospatial Consortium’s (OGC) latest interface standards OGC API Features and OGC API Coverages (API: Application Programming Interface). A separate layer of functionality has been added to the platform to combine the available content themes into a single service end point and to seamlessly integrate the country-level datasets across national borders. As the final step, an enhanced Web user interface for accessing the GeoE3 integration platform has been designed and developed. The new user interface facilitates visualization, interaction with and download of geospatial content across national borders and thematic domains.

**Keywords**—user interface; data integration; cross-border; OGC API Features; OGC API Coverages.

## I. INTRODUCTION

The Geospatially Enabled Ecosystem for Europe (GeoE3) project has developed advanced service-level solutions for cross-border and cross-domain geodata integration to support renewable energy-related applications [1][2]. By focusing to the needs of a well-defined use case, the project could focus on developing data integration solutions for a limited number of data sets. Energy-related use cases focused on solar energy necessitate the availability of 3D buildings, Digital Terrain Models and Digital Surface Models. A considerable effort was done to make 3D buildings available on the platform. 3D buildings are available from all participating countries, either as genuine Level of Detail 2 (LoD2) models or as experimental LoD1 models, dynamically generated by the service [3].

Based on the selected use cases, integration of climate attributes was also deemed important. The data portals of national meteorological agencies were accessed to retrieve climate information and the resulting point observation values were transformed to an interpolated coverage. Further on, the coverage is queried with a point location to derive a climate value for instance for an individual building [4].

An enhanced Web user interface has been developed to efficiently visualize, interact with and access the datasets available on the service platform of the project. The user interface is divided into two sections: one supporting easy access for the general public and the decision-maker level users and the other aimed at professional software developers.

The rest of the paper is organized as follows. Section II introduces the GeoE3 integration platform. Section III discusses the solutions used for integrating the separate datasets together. Section IV describes the new enhanced two-part user interface. The paper ends with final conclusions in Section V.

## II. INTEGRATION PLATFORM

The GeoE3 integration platform is a cloud-based service providing single point access to all thematic content offered by the project [5]. The platform is predominantly based on pygeoapi, a Python implementation of the OGC API family of service interface standards [6]. On the GeoE3 platform, pygeoapi has been adapted to run on top of the web service development framework Django [7]. The capabilities of pygeoapi have been extended in the project, for example to facilitate the use of multiresolution raster data storage.

The platform provides harmonized access to the following themes: 2D/3D buildings, 2D/3D roads, Digital Terrain Model (DTM) and Digital Surface Model (DSM). In addition, the platform also provides climate-related parameters, like temperature, windspeed and sunshine to support the selected renewable energy-related use cases. At the moment the platform contains altogether 40 datasets/services (2D buildings: 6, 3D buildings: 6, 2D roads 4, 3D roads: 3, DTM: 5, DSM: 5, temperature: 5, windspeed: 4, sunshine: 2). Most of the datasets are accessed from the country-level services in query time.

Specialized content provider modules have been developed within the pygeoapi software to access national service end points providing data in national schemas. The integration platform takes care of all required harmonization procedures to make the content offering consistent across national borders.

Participating countries are treated as individual data collection datasets inside the single theme-specific OGC API service instance. For example, the theme ‘Buildings 2D’ contains currently five data collection datasets, one for each participating country. This arrangement enables natural cross-border data integration inside a single service end point.

### III. INTEGRATION APPROACHES

The project’s work in implementing OGC API Features and OGC API Coverages standards on the access interface of the platform deviate in some significant aspects from the traditional approach [8][9]. For instance, the GeoE3 services aim at maintaining the map zoom-in metaphor in content access. Instead of relying on tabular, paged feature browsing, the GeoE3 user interface allows for map zoom-in and panning while locating the user’s area of interest - which might cross national borders. Data retrieval is commenced only when the zoom level of the map in the user interface has reached the pre-defined minimum value. In the case of the raster datasets and the OGC API Coverages access interface, the multiresolution nature of the source datasets makes it possible to enable visualization and content retrieval across the whole scale range. For this to work, support for the processing of ‘scale-size’ parameter was added to the base software pygeoapi [10].

To facilitate the map-browsing based content retrieval, support for a background map was added relying on map services provided by national mapping agencies. In the integrating visualization view, Explore, OpenStreetMap is used as the background map.

The handling of Coordinate Reference Systems (CRSs) is a challenging task in the applications integrating content across borders and domains. In the case of the GeoE3 Integration Portal, several CRSs have to be supported. In the OGC API Features services the output CRS is required by the standard to be the longitude, latitude WGS84 CRS. As the national level services are mostly based on Web Feature Service (WFS) standard, the request can be made in the desired CRS, using WGS84 in this case, and no coordinate transformations are needed on the Integration Platform. However, the order of the CRS axes still requires careful consideration in the computing processes on the Platform.

In the case of the raster data and OGC API Coverages, the issue is a bit more complicated. In the country level services, the raster data content is stored in the national CRSs. In the GeoE3 Portal, the access interface accepts queries only in the national CRS. In the map application of the user interface, the query bounding box is transformed to the national CRS and the returned dataset is again transformed to the projection of the map application. This transformation causes the raster image to warp. To ensure that the resulting image will fully cover the map viewport, the request bounding box has to be somewhat extended by the service.

While doing integrated visualization in the user interface, the map application is using the OpenStreetMap background map with Pseudo Mercator CRS. The requested raster dataset, potentially crossing national borders, must be projected to the Pseudo Mercator CRS and integrated into a same image by the Integration Portal.

### IV. USER INTERFACE

The new Web user interface of the GeoE3 integration platform has been enhanced significantly to support easy access to all provided geospatial content. The user interface has been published in the dedicated Web domain [locationeurope.eu](http://locationeurope.eu) and aims at promoting the use of the already existing content and

also encouraging new organizations to join the platform as data providers.

The development of the Web user interface has been guided by a professional Web designer and is based on the use of the Bootstrap framework [11]. Map-related functions of the user interface are based on the widely-used Web map library OpenLayers [12]. The user interface is branded according to the Finnish Location Innovation Hub styling and is being further developed and marketed in the context of this initiative.

The most significant new idea in the user interface design is the division of the functionality into two separate parts, aimed at two distinct user groups: decision-makers and general public on one hand and professional software developers on the other. The part designed for the latter group follows closely the API structure of the OGC API family of standards and is similar with the pygeoapi default user interface and many other implementations of the OGC API standards. The part aimed at decision-makers and general public is more innovative and provides some brand-new functionalities.

At core of the decision-maker’s user interface is the Explore map view that provides an integrated view to all content available on the integration platform. In the Explore view, all the content themes are listed and can be visualized on top of the OpenStreetMap-based background map. The user interface thus aggregates the output of several individual OGC API Features and OGC API Coverages services into a single map view. Behind the service end point, the platform combines all country level services of each theme as a single integrated output. On the Explore view, the country polygons are shown to indicate, in which areas all the currently active themes are available, see Figure 1.

The new cross-theme integration creates a new conceptual computing layer on top of the theme-specific service instances that takes care of the content integration tasks, see Figure 2. In this arrangement, the integration layer treats the theme-specific services as its data collections and the country-level services, that formerly were seen as data collections, are now behind the scenes automatically combined as a single seamless theme.

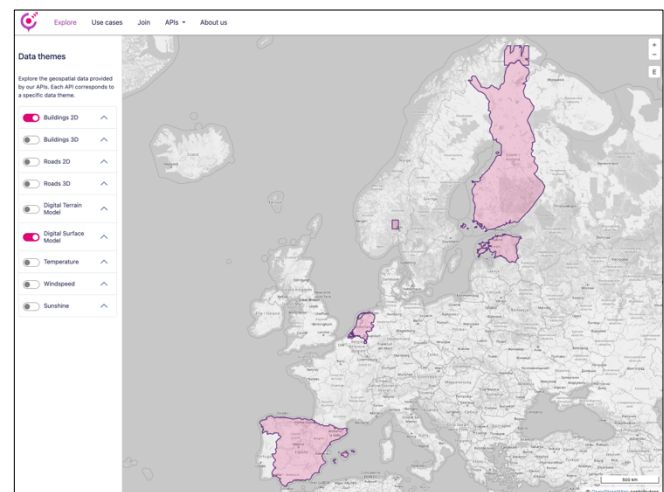


Figure 1. The Explore view with two themes selected and the areas, from which those themes are available, shown as coverage polygons.

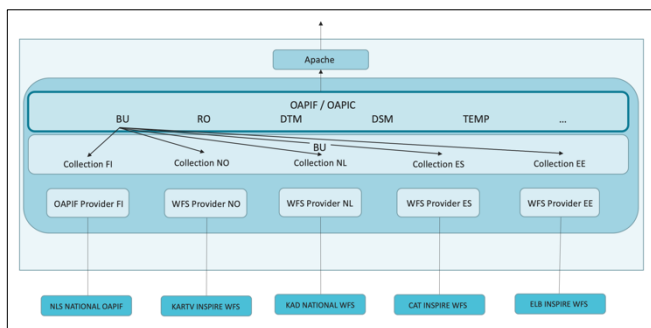


Figure 2. The new computing layer on the integration platform, responsible for combining the themes together and performing automated cross-border integration (Buildings (BU) as an example).

During the query processing, the integrating layer has to overlap the query bounding box with the country polygons to determine, which background services have to be included into the process. The resulting individual country-level responses have then to be combined into a single dataset. The processing involves several CRS transformations, carried out both on query parameters and on the response data.

The Explore view also allows the user to switch individual countries' datasets on and off in the map view, if desired. This functionality necessitates information about the visible countries to be passed to the server side. For this purpose, a new query parameter 'collections' has been introduced to the service request. This represents an extension to the OGC API Features and OGC API Coverages service interface specifications and has to be regarded as an experimental function. However, this functionality closely resembles the concept 'cross-collection query' that was originally introduced in the OGC API Features Part 3, but finally removed from it in the published standard document [13].

In the integrated Explore view, several vector themes, like buildings and roads, can be visualized together. From the available raster themes, only one can be visible at a time. This enables the user to visualize for instance a Digital Terrain Model or a Digital Surface Model together with buildings and roads, see Figure 3. The opacity of each content layer can be adjusted individually.

Buildings and roads can also be viewed as three dimensional objects. A 3D visualization tool called ThreeJsViewer, developed by the Delft University of Technology's 3D Geoinformation group [14], is used for visualizing of and interacting with the 3D models in the Web browser, see Figure 4. 3D content is requested from the integration platform via the OGC API Features interface and encoded in the CityJSON format [15]. The content integration capabilities of the integration platform enable cross-border visualization of 3D models, too, see Figure 5.

In some cases, the LoD1 3D building models are created dynamically by the integration platform using building 2D footprints and heights derived from DTM and DSM. In the case of Spanish buildings, the 3D model is generated by utilizing knowledge about the number of floors in each part of the building, see Figure 6.



Figure 3. The Explore view showing Buildings and Roads, requested from an OGC API Features service interface, together with Digital Terrain Model, requested from an OGC API Coverages interface.

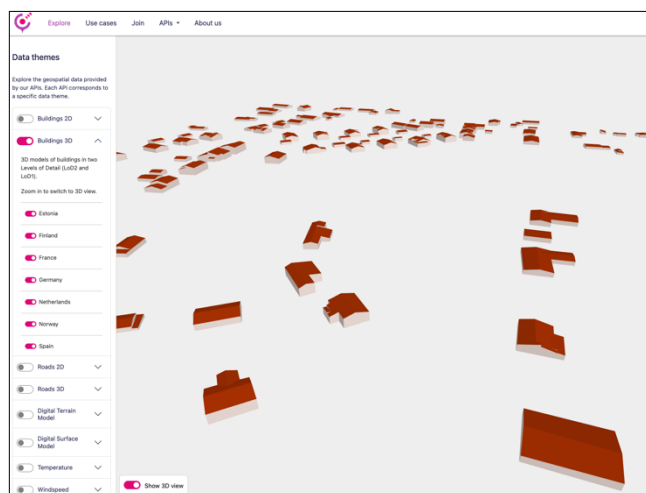


Figure 4. The Explore view showing 3D Buildings, visualized with the ThreeJsViewer component.

The starting page of the user interface represents at the same time the landing page of the integrated cross-theme service end point. All the available themes are introduced already on this page to smooth the browsing experience of an uninitiated user. The landing page thus also includes information usually available on the 'collections' level of the API. The themes are presented as info cards containing an example image of the theme visualization and direct links to the corresponding API landing page and to the Explore view, see Figure 7.

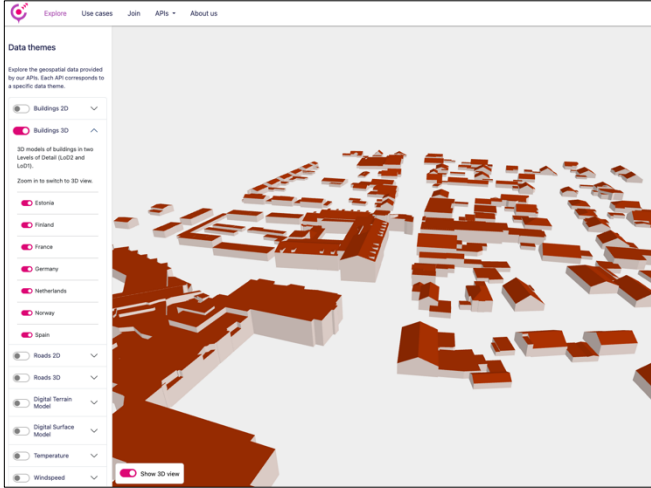


Figure 5. The Explore view showing 3D Buildings in a cross-border area (Dinxperlo, The Netherlands, on the left and Suderwick, Germany, on the right).

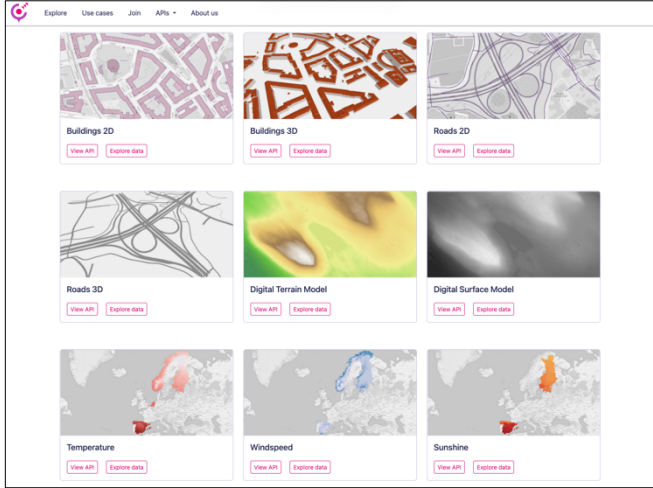


Figure 7. The info cards on the landing page introducing the available content themes (Describe Collections in the OGC API).

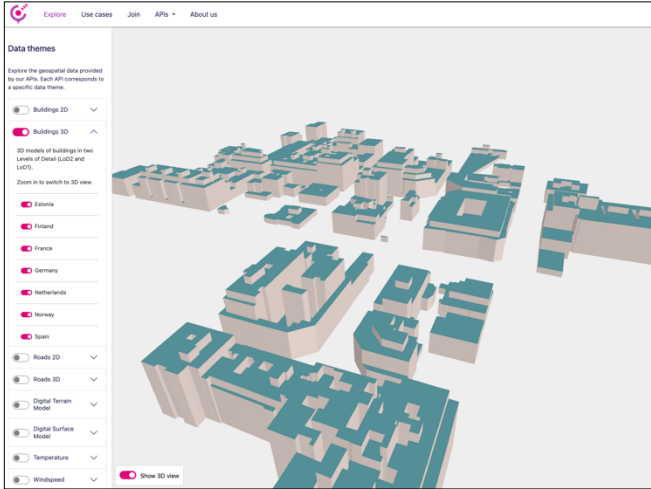


Figure 6. Dynamically created LoD1 3D models, based on buildings' 2D footprint and information on the number of floors in each building part (Barcelona).

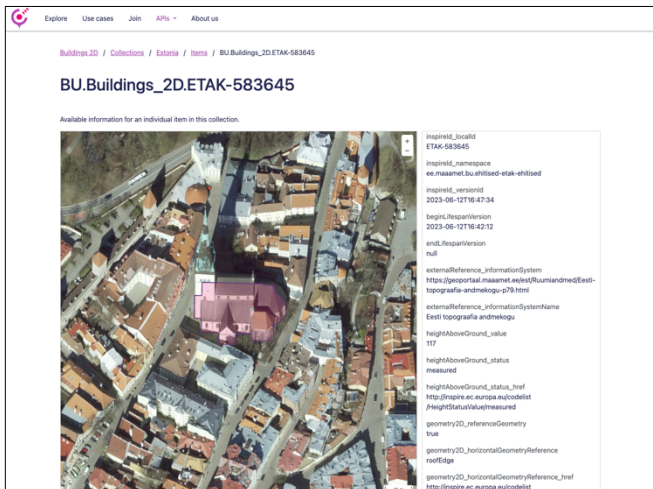


Figure 8. A single vector item, a Building, in the API view (Get Item), (Oleviste Church, Tallinn).

Other functionalities provided by the user interface for decision-makers' category include pages for introducing the current members of the data provider network and a page for joining the network as a new content provider.

The user interface designed for the developer community strictly follow the API structure providing separate Web page for the API landing page, collections list, description of a collection, collection items or collection coverage, and the collection item for visualization of a single vector feature together with its attributes, see Figure 8.

Additional user interface pages for the developer include a page for requesting a free API key required for direct calls to the APIs from the user's own application, and a page providing detailed instructions on the formulation of the queries.

V. CONCLUSION

A flexible geodata integration mechanism has been established on the GeoE3 integration platform. Participating countries' datasets are treated as individual data collections inside an OGC API Features or an OGC API Coverages service instance. This setting enables easy cross-border integration of geospatial content. A new layer of functionality has been developed on top of these theme-specific OGC API service nodes. This layer combines all themes into a single service end point and carries out cross-border content integration automatically behind the scenes. As an extension to the OGC API standards, the service also supports a query parameter 'collections' enabling the client side to dictate, which countries' datasets are to be included in the response, if desired.

A new enhanced Web user interface has been developed to access the data offerings available on the GeoE3 integration platform. The user interface supports easy viewing of all the

content on the platform by providing a cross-theme Explore map view, by which all content themes from all participating countries can be accessed. The Explore view also contains facilities for interactive visualization of 3D content – enabling even cross-border viewing of 3D objects. A separate section of the user interface supports the traditional developer-oriented approach, in which the structure of the Web pages directly reflects the structure of the API itself.

The cross-border and cross-domain content integration functionality offered by the GeoE3 integration platform facilitates applications requiring access to harmonized geospatial datasets throughout Europe, specifically supporting renewable energy-related use cases. In particular, it supports the efforts of companies working in this domain to expand their operations across national borders.

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