Pla_Rel_Corona

Planning reliability for suffering industries and customers during COVID

Final Project Report, WS 2020/2021

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1 The Need for a Transnational Dashboard

Still, one year after the outbreak of the Covid-19 pandemic, a lot of dashboards still focus on the development of the pandemic within national boundaries. Due to this focus on administrative boundaries a lot of information is lost, for example the occurrence of Covid-19 infections within neighbouring districts, or not accessible, because of language barriers, or are only available in unfitting resolutions. The lack of a standardized international or transnational overview of the Covid-19 development creates additional barriers for people and industries acting outside or between national borders. One group which is hurt especially during this pandemic are the industries of tourism, culture, and entertainment as well as their customers.

As a part of the course "SDI Services Implementation", we tried to address this shortcoming for a specific number of adjoining European countries (Austria, Belgium, France, Germany, Italy, Netherlands, Liechtenstein, Luxembourg, and Switzerland). We built a spatial data infrastructure consisting of three ArcGIS Feature Services that provide information on the current Covid-19 situation and have integrated these into a dashboard. The goal is not only to overcome the shortcomings of the national dashboard but to create interactive services within the dashboard that allow planning reliability for the users. In contrast to the available international dashboard, we provide these services on a district level (NUTS3).

In order to guarantee transparency and reproducibility of the project, we provide all the relevant data links, helper tables and the corresponding Python script, pushing the Covid-19 data, within the Gitlab repository. For additional questions on specific parts of the workflow, you can contact us by mail.

In the following chapter, we are going to break down or project concept and overall workflow (chapter 2). After that, we are going to describe the individual work packages behind the spatial data infrastructure (chapter 3). Thereafter, we are going to discuss the project outcome and go over the shortcomings and compromises which were needed for the spatial data infrastructure (chapter 4).

2 Project Concept and Goal

The following chapter will further outline the self-imposed project goals and go into the overall project setup and structure. A midterm report containing the definition of work packages and overall goals has already been created as part of the project management of the project which can be found in the Gitlab repository. The most important points from this report will be summarized here.

2.1 Project Description

In the beginning of the project realisation, the project goals were defined as part of an assignment within the course. They were described therein as the following:

The goal is to build a SDI including several WFS or other services providing information about the actual COVID-19 situation for the countries Austria, Belgium, France, Germany, Italy, Netherlands, Liechtenstein, Luxembourg and Switzerland in an harmonized manner and a dashboard integrating these services. This transnational SDI should help the suffering industries of tourism, culture and entertainment and their customers to get more sophisticated planning reliability by being able to compare the Covid-19 situation throughout Western Europe. It should contain information per region about daily infection numbers, a 14 days trendline of the infection, a 7-day incidence, a prognosis for the near future (if possible), a traffic lights system indicating different levels of risks (threshold values) and historical data (spatio-temporal diagram). A spatial resolution of NUTS-3 level is seeked. Further, it should include an overview of COVID-19 measures taken for each region and if possible additional statistical measurements such as the reproduction number. For a good Human Computer Interaction (HCI) a location search function should be integrated in the dashboard.

In addition, certain usage situations of dashboard were defined in order to identify specific use cases of the dashboard and the underlying SDI.

Ex. 1: When a hotel in a ski resort is getting a demand, they can check the actual COVID-situation with a 14 days trendline of the past to decide whether they accept or reject the admission.

Ex. 2: When an agency is getting a request for an event (building a stage), they can look up the COVID situation in the event area.

Ex. 3: A potential customer can check the actual COVID situation of his/her destination beforehand and decide if he/she wants to book a trip.

The herein defined project goals and use cases will be used as a reference for the evaluation of the project.

2.2 Project Structure

As already outlined in the project description, the realization of such a dashboard requires the creation of a whole spatial data infrastructure providing the according information in a standardised and harmonized manner. We therefore choose to work with a PostgreSQL database (ESRI Geodatabase) to store the Covid-19 data and provide the information for the dashboard via ArcGIS Feature Services which were adapted to the needs of certain dashboard functionalities. The project was therefore split up into seven different work packages to help us organize the overall project workload.

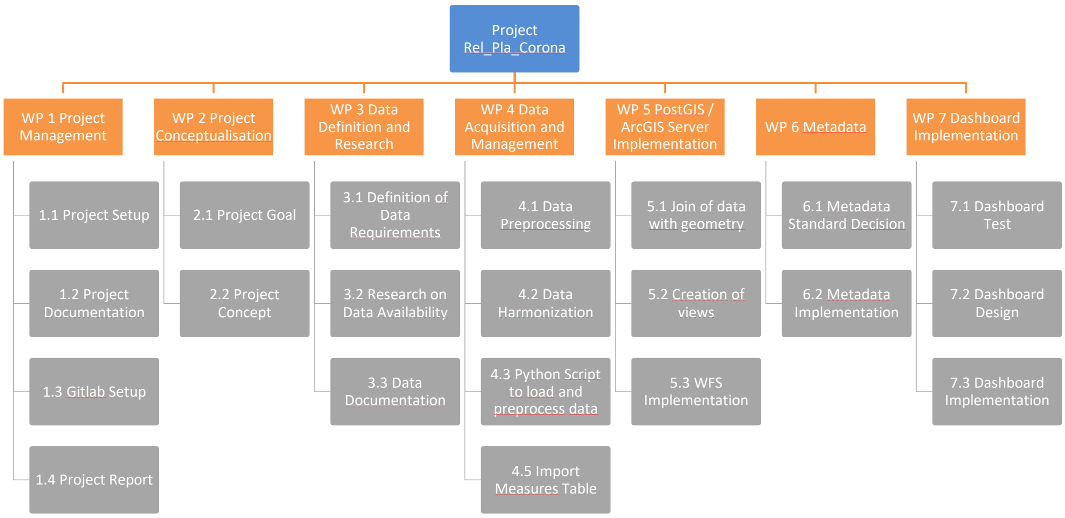


Figure 1: Work Breakdown Structure

Source: own representation.

Figure 1 shows the individual work packages. Within this report we will introduce them swiftly. For a more detailed explanation please refer to the midterm report or the 'Gitlab Issues' section.

The first work package includes the overall project management. In order to guarantee transparency for the overall project, we documented the project development as well as the associated milestones in a midterm report and in a Gitlab repository. The project management was a continuous process alongside the realization of the other work packages in order to ensure that the project is finished within the defined goals and the given time schedule.

The second work package covers the overall conceptualization of the project. Here the goals and project concept were defined that shape the following workflow for the project. With the before outlined project definition, we choose to focus on a specific user group with their specific needs: the industries of tourism, culture, and entertainment as well as their customers. Due to the availability of Covid-19 data and our language skills we selected the following countries for the implementation of our project: Austria, Belgium, France, Germany, Italy, Netherlands, Liechtenstein, Luxembourg, and Switzerland. The project concept further determined the following work packages from data definition to the dashboard implementation.

After defining the group of countries and the use case of our application, we checked first for the available Covid-19 data in the work package "Data Definition and Research". The main part of this work package was to look for the desired data and document the characteristics of the data as well as the resolution. The data research was then captured in an excel file containing all the information on the found data. An overview of the data sources can be found in chapter 3.1. Due to the heterogeneity of the data, ranging from resolution to availability of certain information such as number of deaths and reproduction number, we chose to focus on the Covid-19 cases which were the common denominator between all of the countries. Even though we lost some valuable information on the Covid-19 development in specific countries, we decided to prioritize the general overview and interoperability of the dashboard.

The fourth work package focused on the data acquisition and management within a PostgreSQL ESRI Geodatabase. This work package is dedicated to the data import of the defined Covid-19 data and additional information such as population and geometry. Due to the heterogeneity of the data in structure and resolution, a lot of work had to be put into harmonization of the data. For example, some countries captured the cumulative number of Covid-19 cases instead of the desired number of cases per day. In some cases, the spatial resolution of the data was even better than the district level. Therefore, the preprocessing of the data included aggregation of data, calculation of variables, formatting, and adding of additional information. For a more detailed explanation on the methodology please refer to chapter 3.1 and 3.2.

The fifth work package included all the work on the management of the data on the PostgreSQL server as well as the publication of the specific data subsets. Customized to the specific features in the dashboard (overview of the daily cases and of the last 14 days and historical development of the pandemic) we created three materialized views and published them using the Z_GIS ArcGIS Server. These ArcGIS Feature Services are then daily updated and responsive. For a more detailed explanation on the ESRI Geodatabase implementation and publishing of the data please refer to chapter 0.

In order to make the documented published ArcGIS Feature Services usable for everybody, they need to be documented according to the ISO Standard 19139. We therefore used the metadata editor ‘Geonetwork’. The creation of the metadata is covered in the sixth work package. The resulting metadata documents are stored in the Gitlab repository as pdf and as xml files.

The final work package is dedicated to the overall dashboard implementation and design. Due to the large workload in the work packages 4 and 5 we decided to go with the ArcGIS framework to create our dashboard. This simplifies certain tasks and relieves us of the work to design a HTML web page but also comes with its limitations. The most important part for the dashboard design was the use of interactions within the dashboard. The user should be able to select and query information about certain districts and regions depending on their interest. It is further explained in the chapter 3.5.

3 Methodology

In this chapter, the four logical tiers are described that are needed to build the required infrastructure of our Covid-19 dashboard. All of the tiers are relying on ESRI Technology. The data tier is based on a python script querying data from the web on a daily basis, before manipulating and pushing it to a ESRI Geodatabase on Postgres. For creating our transnational web application (9 countries), standardization respectively harmonization of the heterogeneous data is indispensable and is guaranteed by adapting all information to a predefined table structure containing attribute names and data types. The server tier, as the second component, is needed to power our GIS services and to process client requests. We are using an ArcGIS Server providing not only ArcGIS Rest Services but also OGC conform WMS and WFS. By publishing a daily, 14 days and historical view on the Covid-19 pandemic we enable the various requirements of our dashboard in the best way possible. Before using those services right away in the last tier - the presentation tier -, another tier (portal tier) is required to make a dashboard working in the ESRI environment. Feature services must be imported into a 'web map' (or 'web scene') of either the ArcGIS Online or ArcGIS Enterprise portal to be accessible in any of the ESRI applications. The ArcGIS dashboard allowed us in the last tier to convey the information about the current Covid-19 situation in an intuitive and interactive manner by using map and time series elements for the data visualization.

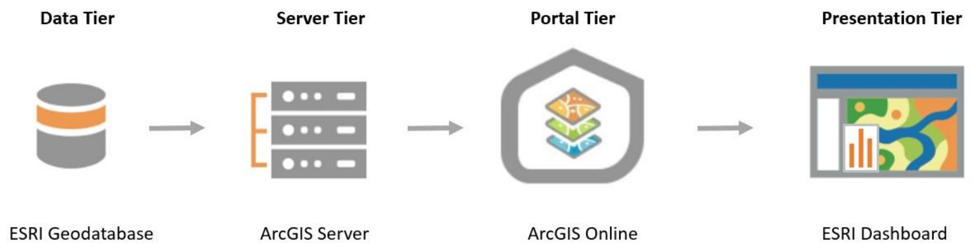


Figure 2: Project Tiers

Source: own representation.

3.1 Data Import

For our project of a transnational web dashboard application, we access daily Covid data from official institutions that can be ministries, authorities, or research institutes of the respective countries. Table 2 shows an overview of the data owner and links to the data source. The structure of these datasets varies heavily. The only attributes known to all tables are time, a national reference ID referring to an administrative unit and the number of Covid cases (see Figure 3).

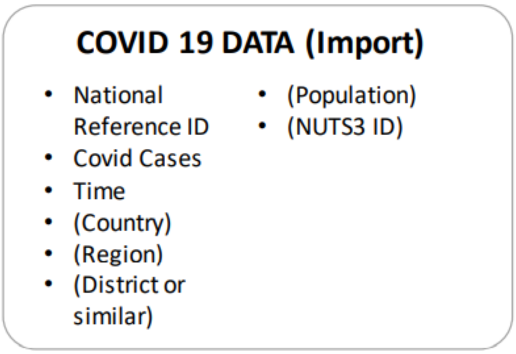


Figure 3: Attribute Overview of the Covid-19 Data Imort

Source: own representation.

Other attributes like the name of the administrative unit, the population, the region/province/state, the country or the ID of the European statistical unit NUTS3 is sometimes available. The spatial and temporal resolution of these datasets meets the requirements of the project. The temporal resolution of a day and the spatial resolution of NUTS3 (similar to the national administrative unit of district, arrondissement or county (see table 1)) or equivalent allows us to create daily updates and to identify small-scale differences on the Covid situation. A peculiarity of the Belgian and the Italian datasets is the declaration of Covid cases as cumulative values. A disaggregation during the data processing solves it. Further, for Belgium and the Netherlands, the data is broken down to the municipality level and has to be aggregated later on.

Table 1: Overview of the Data Owner

Countries	**Spatial level of original dataset**	**Identical to NUTS3**
Austria	district	No
Belgium	municipality	No (aggregation to NUTS3 level possible)
France	department	Yes
Germany	county	Yes (exception: Berlin)
Italy	province	Yes (exception: Sardinia)
Liechtenstein	country	Yes
Luxembourg	country	Yes
Netherlands	municipality	No (aggregation to NUTS3 level possible)
Switzerland	canton	Yes

Source: own representation.

Besides the official Covid datasets we need additional data to harmonize them. On the one side we have to supplement the Covid data with population and names for administrative units (country, region, …). On the other side we have to connect the national reference ID with its European counterpart NUTS3 ID, that will later serve as spatial fundament and can be linked to the NUTS3 geometry dataset. All countries except for Austria are allowing this connection because both administrative units (NUTS3 & national reference) are, except for minimal differences, identical. In Austria, the Covid data is resolved on district level, but unfortunately the boundaries of the national districts differ too much from the NUTS3 areas. Therefore, it will be based throughout the project on their national administrative units with the consequence that the geometry dataset will be a union of NUTS3 elements and Austrian administrative boundaries. For a better scale matching between both geometry files, we used the 'Europe_NUTS_3_Demographics' (2016) dataset from ESRI having a better resolution than the available dataset on the EUROSTAT website (see table 2). The supplemented attributes population (NUTS3 population 2019) and the name of the administrative units (NUTS3 names) are derived, except for Austria, from the EUROSTAT website due to harmonization reasons (see: table 2) [1]. In order to establish the link between NUTS3 ID and the national reference ID (see chapter 3.2), national administrative boundaries (matching the Covid data) were downloaded for most countries [2] (see table 2).

Table 2: Overview of the Data Origin

Countries	Data provider / publisher	Data source (URL)
Austria	AGES (Agentur für Gesundheit und Ernährungssicherheit GmbH) / OpenData Portal Austria	Covid Data
	Statistik Austria / Open Data Austria	Administrative Boundaries (geometry)
Belgium	Sciensano / EPISTAT	Covid Data
	FEDERAL PUBLIC SERVICES FINANCES (FIN)	Administrative Boundaries (helper geometry)
France	'Ministère des Solidarités et de la Santé' / Data Portal France (data.gouv.fr)	Covid Data
	OSM /data.gouv.fr (French Data Portal)	Administrative Boundaries (helper

[1] 'Europe_NUTS_3_Demographics' also contains a population column but is outdated (2016).
[2] except for Luxembourg, Liechtenstein & Switzerland. In the case of Switzerland, the linkage was done manually.

		geometry)
Germany	Robert Koch Institute / Open Data ArcGIS	Covid Data
	ESRI based on Bundesamt für Kartographie und Geodäsie (BKG)	Administrative Boundaries (helper geometry)
Italy	Department of Civil Protection	Covid Data
Luxembourg	Ministère de la Santé / data.public.lu	Covid Data
Netherlands	National Institute for Public Health and the Environment (RIVM)	Covid Data
	Public Services on the Map (PDOK) / National Georegister	Administrative Boundaries (helper geometry)
Switzerland & Liechtenstein	Federal office of public health	Covid Data
All countries (exception: Austria)	ESRI based on EUROSTAT	NUTS3 Boundaries (2016) (geometry)
	EUROSTAT / EU Open Data Portal	Population

Source: own representation.

3.2 Data Preprocessing

Before doing the actual processing of the data the creation of helper tables was needed which are supplementing Covid datasets with missing information and the NUTS3 reference code. This harmonization allows us later to push all required attributes to a predefined table schema (see figure 3). The structure of those helper tables are not uniform due to the inconsistency of the Covid data (and the additional data sources) [3].

Nevertheless, a general procedure of these tables can be described. The first and most important step is a perfect linkage between the Covid dataset and the national administrative boundaries as well as a linkage between the latter with the NUTS3 geometry. In most cases the national administrative boundaries are matching the Covid datasets. When this was not the case adjustments were made. Table 3 shows an overview of these exceptions:

[3] The number of attributes varies per table. Some of them are not used during the process, they only served as a potential alternative to other attributes. For some countries multiple smaller helper tables exist in the form of a csv located on Gitlab (or external website) or as a json object directly integrated in the python code contributing partly to the required information. In the end all those tables and attributes are guaranteeing the harmonization of the table that is pushed to the database.

Table 3: Overview of the Exceptions

Vienna is represented as whole and not on district levels in the Covid dataset	District boundaries of the capital were dropped
The metropole of Lyon and the department of Rhône are considered to be one	Both deptartment boundaries were merged
Several regions were aggregated on Sardinia for the Covid dataset (from 8 to 5)	Region boundaries of Sardinia were adapted

Source: own representation.

A further measure to ensure data quality was the dropping of the overseas territories of France due to data inconsistency. The connection between national administrative boundaries and the NUTS3 dataset is based on a spatial analysis where the administrative boundaries are converted into centroids and joined spatially one-to-many with the NUTS3 geometry (exception: Austria). Furthermore, this allowed on the one hand the linking of the municipalities in Belgium and in the Netherlands as well as the districts of Berlin [4] with the coarser NUTS3 level. On the other hand, one mismatch could be detected and corrected. In 2019 an administrative merger between the districts of ‘Göttingen’ and ‘Osterode am Harz’ took place and wasn't yet integrated in the ESRI NUTS3 dataset.

By linking the reference codes, further content such as the names of the NUTS3 areas was brought together at the same time. To ensure a coherent population attribute the respective dataset is connected via the NUTS3 reference code with the helper tables.

The python script as the central element of the preprocessing procedure is responsible for the daily import of the Covid data, its linking with the auxiliary tables, the manipulation and harmonization of the data, the calculation of additional attributes such as trend and incidence values as well as the push of the data to the ESRI Geodatabase. The manipulation includes the disaggregation of the cumulative Covid cases by subtracting the Covid cases from the previous day (Italy & Belgium) via a for loop or a groupby.diff() function (pandas library) and the aggregation of the municipality cases on NUTS3 level (Belgium & Netherlands) with the help of a simple groupby() function (pandas library). Due to potential inconsistencies of the cumulative values in the datasets, negative results can occur and must be eradicated by setting them to 0. The harmonizing process is referring to a unification of the data in terms of (re)naming attributes, defining data types and selecting only required attributes. This harmonized data frame is then updated with additional trend and incidence attributes by the get_trend_and_incidence() function.

[4] The NUTS3 level is in Germany identical with the district level except for Berlin where the NUTS3 dataset is using the state boundary of Berlin as reference.

The trend attribute is based on the slope respectively the coefficient of a linear regression describing the relationship between time and Covid cases and is calculated on the basis of the last 14 days for a specific date and its NUTS3 area. To make use of the linear regression function time must be converted into a relative day count (starting date: 01.01.2020). The basis of 14 days has been chosen as a good approach to reduce the impact of lower cases during the weekend. This method should be considered as an approximation. Other regression models that are not based on a straight line might be better in predicting the real trend! For the incidence values we calculated the daily incidence, a simple division of the Covid cases by the population, the 7 days and 14 days incidence. The last two values are based on the sum of Covid cases over a specific number of days (7 or 14) and are then divided by its population. For reducing the overall execution time of the script, the trend and incidence values are only calculated for the last 14 days of the dataset. The last task of the script is to push the data of all countries into an already previously defined table structure (one table) of the ESRI geodatabase (see: figure 3).

Besides the harmonized Covid table ('covid_data'), the 'covid_countries' (geometry) and another table containing links to the Covid measures were imported into the database (see Appendix A). The Covid countries table refers to the merged geometry of the NUTS3 and the Austrian district datasets. For a perfect matching of both in terms of scale and borderline, the Austrian districts have been generalized (simplification of the polygons) and snapped to the NUTS3 outer border.

```
-- SQL Template
CREATE TABLE schema.covid_data
 (
     id serial,
     "time" timestamp without time zone,
     country character(50),
     region character(150),
     district character(150),
     districtid character(50),
     cases_daily integer,
     population integer,
     geom_id character(20),
     geom_name character(150),
     trend REAL,
     incidence_daily REAL,
     incidence_7 REAL,
     incidence_14 REAL,
     PRIMARY KEY (id)
 );
```

Figure 4: SQL Code Snippet

Source: own representation.

3.3 PostgreSQL

The database is used to store the daily pushed data from the script in a predefined table structure, which in turn is the data source for the feature services representing the current Covid situation. Before this daily push is executed, the table is truncated. This decision does not rely on any infrastructure reason but is done to assure retrospective changes to the datasets from the data providers. The three tables - covid_data, covid_countries, covid_measures - which can be found in the database are the data sources for the three materialized views. The daily view (‘sdi_covid_daily_view’) contains the latest day of all countries of the covid_data table and is joined with the covid_measures as well as the covid_countries (polygon) table. The 14 days view (‘sdi_covid_14days_view’), as the name already implies, incorporates the last 14 days of the Covid table where each row is geographically represented by a coordinate (Join with covid_countries as centroid). The third view - the historical view (‘sdi_covid_hist_week_view’) - provides a holistic review of the Covid pandemic on a weekly basis. It shows the summed up Covid cases for each feature (geom_id = NUTS3 ID or Austrian district ID) and week. Therefore, the corresponding week of the year is determined for each date and then used as an input to aggregate the data based on a groupby() function. Further it will be joined by the geometry table as centroids to assure the ArcGIS Feature Service capabilities. To make the views compliant with an ESRI geodatabase all views must be registered with the database (‘Register with Geodatabase’ in ArcGIS Pro). Our design decision to use materialized view is based on the ability to precompute expensive joins and aggregations that are stored in ‘temporal tables’ and to keep the flexibility of the traditional views (ex. up-to-date data) by simply refreshing the materialized view.

3.4 ArcGIS Feature Service

After creating the materialized views in section 3.3, they need to be published as Feature Services in order to be successfully integrated into the ArcGIS Dashboard. Therefore, the materialized views were imported into ArcGIS Pro within a map and then made accessible as a Web Feature Service (WFS) and as a Web Map Service (WMS) within the designated folder “20W856162” of the Z_GIS ArcGIS Server. Apart from publishing both services in an OGC conform manner, it was also published as an ArcGIS Feature Service (Feature Access) to be used more efficiently within the ESRI environment.

For additional information, the three web feature services were documented according to the ISO 19139 Standard in order to ensure universal transparency of the data. Therefore, the Z_GIS metadata editor ‘Geonetwork’ was used. An overview of the materialized views, ArcGIS Feature Services and the associated metadata is provided below. The metadata can also be accessed as xml files within the Gitlab repository.

Table 4: Overview of the Materialized Views, Feature Services and Metadata

Table / Materialized View Name	**ArcGIS Feature Service / WFS**	**Metadata**
covid_data, covid_countries, covid_measures	-	COVID Data for Western Europe
sdi_covid_daily_view	s1069585_covid_views - w20_856162_sde.s1069585.sdi_covid_daily_view	COVID Data for Western Europe (Current Cases) - Web Feature Service (WFS)
sdi_covid_14days_view	s1069585_covid_views - w20_856162_sde.s1069585.sdi_covid_14days_view	COVID Data for Western Europe (14 Days) - Web Feature Service (WFS)
sdi_covid_hist_week_view	s1069585_covid_views - w20_856162_sde.s1069585.sdi_covid_hist_week_view	COVID Data for Western Europe (Weekly View) - Web Feature Service (WFS)

Source: own representation.

In order to document the data sources of the Feature Services, an additional metadata document (geonetwork: dataset) was set up containing information on the datasets ‘covid_data’, ‘covid_countries’ and ‘covid_measures’. This metadata document ‘COVID Data for Western Europe’ describes a theoretical dataset that represents a join of all three database tables. The metadata document on the dataset was then referenced within the other metadata documents for the Web Feature Services.

3.5 ArcGIS Dashboard

Before implementing the dashboard, a test dashboard was designed in order to test the functionalities and sketch the overall appearance of the final dashboard. Important for the dashboard is a map area showing the spatial development of the Covid 19 pandemic on a district level. For the additional information, an area was designated to depict figures showing the temporal development. Important for the use case was the possibility to query the data by using spatial and non-spatial selectors and filtering the data depending on interest. All these different sections of the dashboard should be interacting with each other and be responsive to the needs of the user.

In accordance with the first test dashboard, the final dashboard was split up into four main areas: the maps, the figures, an information section, and a sidebar containing multiple filters.

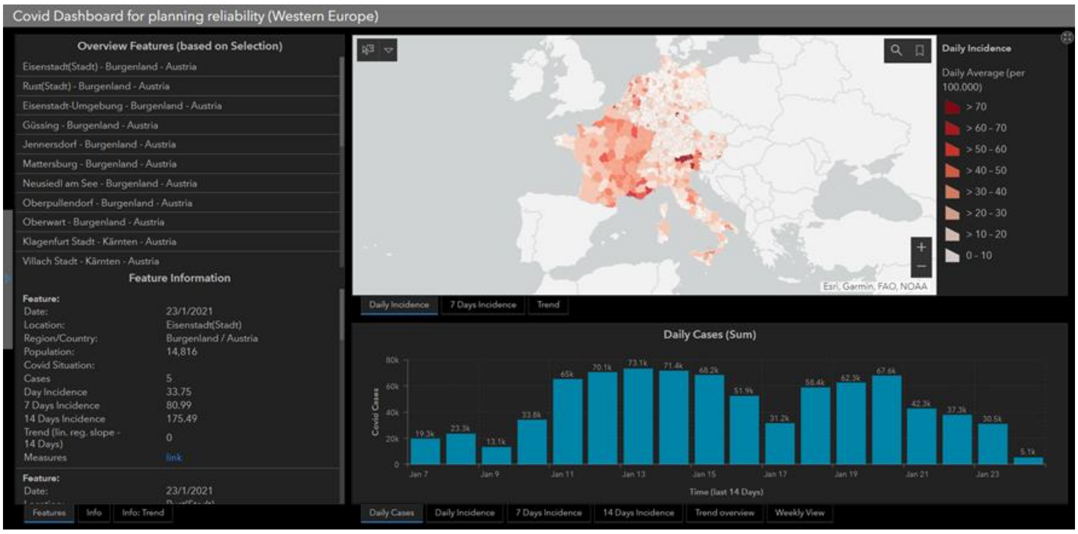


Figure 5: Dashboard

Source: own representation.

For the map area, three web maps were created depicting different information about the Covid-19 development within the districts: One showing the daily incidence value of the district, another showing the incidence value of the district of the last seven days and the last one showing the calculated trend from the last 14 days. The styling of those maps are using customized thresholds (equal intervals) which are inspired by national Covid-19 dashboards (traffic light systems). The three maps are listed in the table below with the corresponding ArcGIS Feature Service:

Table 5: Name of the ArcGIS Web Maps and the Corresponding Feature Service

ArcGIS Feature Service	ArcGIS Web Map
s1069585_covid_views - w20_856162_sde.s1069585.sdi_covid_daily_view (1)	Map for Covid Dashboard - Daily Average
s1069585_covid_views - w20_856162_sde.s1069585.sdi_covid_daily_view (2)	Map for Covid Dashboard - 7 Days Average
s1069585_covid_views - w20_856162_sde.s1069585.sdi_covid_daily_view (3)	Map for Covid Dashboard - Trend

Source: own representation.

For additional functionalities a search function was added to the maps as well as a number of bookmarks which allow to switch the focus of the maps easily. In order to query the data, a selection functionality was included into all of the maps. For the activation of the selection of features within the map a small button is included in the upper left corner. The dropdown menu allows further customization of the selection.

For the figures, the data was first imported as a web layer (ArcGIS Portal) and then imported as a data source for the according figures. As outlined in the dashboard design, the figures primarily depict the temporal development of the Covid 19 pandemic using the development of indicators such as daily cases, daily incidence, 7 day incidence, 14 day incidence and trend for the last 14 days. In addition, the historical development of the pandemic is shown in one figure. For the visualization, an aggregation of the indices is necessary in form of a sum or the mean value in order to showcase the correct development. Unfortunately, the date of publication differs between the countries. This also affects the figures depicting the overall development. Therefore, the newest and the oldest data should be treated with caution when viewing multiple districts from different countries.

The information section of the dashboard consists of multiple layers: one containing an additional selection (’Overview Features (based on Selection)’), an information section (‘Feature Information’), an introduction to the dashboard (‘Info’) and an additional explanation to the concept of the linear regression (‘Info:Trend’). Instead of placing a pop-up window within the map, the attribute table was fixated as ‘Feature Information’. Within the ‘Overview Features’, a selection of different regions and districts are listed. By clicking on one of the listed districts a selection within the maps and figures is made depicting only the information for that district. The information layers function as guidelines for dashboards and its content. On the left side of the dashboard is a sidebar included showing different filtering options. Depending on the interest, the user can select here one or multiple countries, regions or districts (subregions). Additional filter options on indicator parameters are included as well such as daily incidence value, 7 days incidence value, trend and even the days. By selecting certain values within the filtering sidebar, the map and figure content are queried for the according information.

Overall, all of the content within the dashboard is linked with each other in order to allow interactive queries and filtering of specific information (see sidebar, ‘Overview Features’ & maps). The figures, the maps and the pop-up window will adapt to the query and depict the desired information. These functionalities allow the user to quickly and intuitively look for information where he/she has interest in.

4 Result and Discussion

In an overall manner we were able to realize the project as initially thought. Even though there were some challenges in form of different data quality, resolution, geometry differences etc. We managed successfully to create a transnational dashboard giving a broad overview

of the current Covid-19 situation for the industries of culture, tourism and entertainment. In comparison to other dashboards we were able to provide current and small-scale information and allow interactivity for the users. Still, there are some limitations to our dashboard.

We do have some data constraints in terms of timeliness. The latest available data of the Covid-19 situation varies from country to country. The temporal interval of actualization of data does not take place on a daily basis in some countries. Thus, the situation may arise that some countries are up to 6 days behind in comparison to others and this may lead to wrong interpretations when looking at the dashboard in particular at the daily view. Furthermore, the trend should really only be understood as an approximation. Linear regression is based on the premise that the underlying phenomenon can be described linearly. In the case of pandemics and a potential exponential development, this is not necessarily the case. As outlined in section 3.2 the disaggregation of cumulative values, sometimes led to negative values. This is a result of inconsistencies within the individual datasets and can not be solved by us.

The heterogeneity of the data looks at first sight to become a potential problem, but could be resolved with additional helper tables. A future harmonization of such data would nevertheless be desirable. It would significantly facilitate the development of transnational applications. In the beginning a potential integration of the reproduction was desired, but could finally not be implemented due to sporadic and low spatial resolution throughout the countries.

Initially, we intended to create an additional traffic light system for the users to assess the risk within the districts. This was not feasible for a transnational application due to different political definitions of risks.

As outlined in the dashboard design, using the ArcGIS framework comes with its limitations. The integration of official measures websites was not possible and could only be provided via link in the ‘Feature information’ window. The option of embedding external websites was blocked by the website providers. An external WFS containing measures information was detected too late from our side that could have been an alternative. The possibility to have an introductory pop-up window / website in order to give a step-by-step tutorial to the dashboard would have been desirable. In addition, further possibilities to create small explanations (pop-up) within the dashboard were not given which leaves your dashboard sometimes unintuitive. In general a better and more sophisticated guideline is needed to make sure that the user understands the dashboard functionalities.

Overall, the dashboard is structured in a way that the HCI is easy understandable and usable after a bit of training. All of the mentioned use cases from chapter 2.1 can be realised. All the desired functionalities are included (ex. search) and the dashboard is running smoothly despite the huge amount of data that is loaded in the background. The most important information is the map and the associated figures that allow to get an overview on the current numbers and a comparability between different districts, regions and countries.

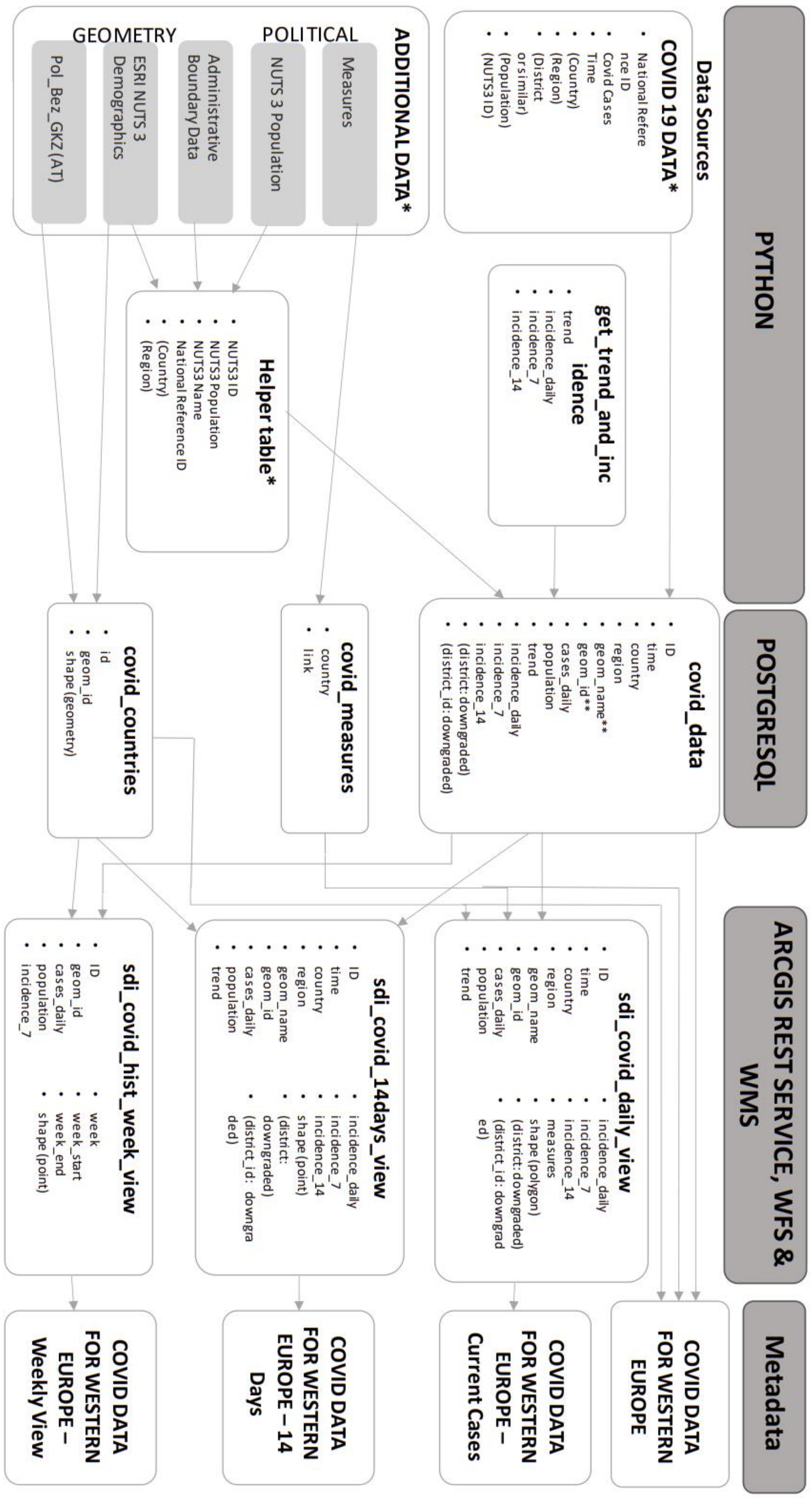
5 Outlook

The intended project of building a transnational spatial data infrastructure including Feature Services and a dashboard application for describing the current Covid situation could be realised. Our dashboard allows high spatial (NUTS3) and temporal (daily) resolution for nine Western European countries (Austria, Belgium, France, Germany, Italy, Netherlands, Liechtenstein, Luxembourg and Switzerland). It allows our user group to quickly look up the newest developments and query for specific use cases.

A major focus has been on the harmonization of datasets coming from different institutions/countries and on an efficient and fast infrastructure which is capable of dealing with huge amounts of data. The integration of a linear regression trend has turned out to be a valuable addition to our dashboard, although it has to be used with caution. An implementation of additional parameters such as a logarithmic regression or a reproduction number would increase the value of such a dashboard.

As mentioned before, one of the main challenges of the project was the handling with the heterogeneity of the data. Even though all of the countries are either part of the European Union or of the European Free Trade Association (EFTA) and thus members of the INSPIRE initiative, we expected a more harmonized data infrastructure. A future harmonization within the INSPIRE initiative is desirable.

Appendix A: Pla_Rel_Model



* can contain proxy attribute names

** union of NUTS3 and Austrian district

Appendix B: National Reference Table of ‘Region’ Naming

Table 6: National Reference Table of ‘Region’ Naming

Countries	**National reference of ‘region’**
Austria	State
Belgium	Province
France	Region
Germany	State
Italy	Region
Liechtenstein	/
Luxembourg	/
Netherlands	Province
Switzerland	Region (statistical unit)

Source: own representation.

Describes the spatial level of ‘Region’ within the Esri Geodatabase tables and Feature Services.