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RUGGEDISED

Designing smart, resilient cities for all

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Decision support Platform (ICT solution) for informing strategy and decision making

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Executive Summary

This document will describe the Data-Based Decision Platform (DBDP) solution implemented in Glasgow and demonstrate how it satisfies the deliverable requirements set out in the bid document, specifically Smart Solution G7. This is a Bare Bones Report to demonstrate deliverable has been met.

The purpose of this document is to describe the Data-Based Decision Platform (DBDP) solution developed by Glasgow City Council (GCC) and demonstrate how it meets the deliverables set out in the bid document.

The report includes a link to, and screenshot of, the fully formed data based decision ICT platform that integrates open data generated by the deliverables in WP4, as well as existing data (both with and external to GCC) and data generated by connected sensors deployed through a series of complimentary smart city initiatives, funded externally to the project. In addition, a couple of Use Cases are used to illustrate how the solution works.

Solution Location

The DBDP is available to users at the following location:

https://databased.site

This link is available to users both within and external to GCC.

Demonstration Video

A demonstration video has been created to show the operation of the tool. The 2 Use Cases discussed later in the document are illustrated in the video.

The video can be downloaded from the following location:

DBDP Video

Contents

1 Introduction

This document will describe the Data-Based Decision Platform (DBDP) solution implemented in Glasgow and demonstrate how it satisfies the deliverable requirements set out in the bid document. This is a Bare Bones Report to demonstrate deliverable has been met.

The purpose of this document is to describe the Data-Based Decision Platform (DBDP) solution developed by Glasgow City Council (GCC) and demonstrate how it meets the deliverables set out in the bid document.

The report includes a link to, and screenshot of, the fully formed data based decision ICT platform that integrates open data generated by the deliverables in WP4, as well as existing data (both with and external to GCC) and data generated by connected sensors deployed through a series of complimentary smart city initiatives, funded externally to the project. In addition, a couple of Use Cases are used to illustrate how the solution works.

1.1 Solution Description

This is found on page 46 of the RUGGEDISED bid document.

Smart Solution G7: Smart open data Decision Platform/central management system
RUGGEDISED will build upon the existing open data platform and Energy App by creating a 'Data Based Decision Platform' (DBDP). The DBDP will take data feeds created by the project RUGGEDISED and include existing datafeeds in the city to create a platform where users (the Local Authority, businesses, citizens, academics, etc) in the city can run queries based on analysis of the available data. An example of how this is specifically relates to the project is in the collection of data from electric vehicle users looking for available parking spaces in the city. Through the raising of a query, users will be able to see instances of other users having tried to locate a space and failed. The volume of fails per pre-determined time period could be used to assess the need to expand the existing charging infrastructure, or to develop a new charging hub at another point in the city. The development of Smart Solution G7 will be managed by Glasgow City Council through its 'City Data Team'.

If the above query was run in tandem with a query on existing heat-map data, using the national heat map created by the Scottish Government for the promotion of low energy and district heating solutions, and data sourced from the Energy App, it could be possible to locate a new electric vehicle hub in an area where renewable power would be particularly suitable, or where and industrial process could provide an economic advantage to development of an energy storage centre. The analytics developed will continue to evolve as more data sets become available and the level of queries becomes ever more sophisticated.

1.2 Task Description

This is found on page 47 of the RUGGEDISED bid document.

Task 4.5 Smart city services to the community (Lead:) [M1-M60]
This task is intrinsically linked to all of the previously set out tasks in this work package. The tasks each provide a direct or indirect facilitation of access to smart city services in the community.
The DBDP, described above takes all of the data produced by the interventions listed in the WP and combines it with existing open data sets, providing a tool that will provide the analytical engine to allow citizens and businesses in the community to better access and analyse open data. Through this analytical assistance, citizens will be better placed to contribute to solutions both specific to their community and to the wider city.
The development of the DBDP as a user driven system, combined with the development of the innovation hub, will bring about added benefits to the city through the inclusion of a variety of user inputs and queries raising issues and creating solutions that were previously more difficult to realise by creating a technical software tool and physical space in which users with requirements and users with solutions can interact and work together to derive solutions.

Through the development of DBDP in T3.6.1, an ICT tool will be created that takes open data and incorporates into a query based geo-spatial database, allowing strategic replication decisions to be made that are based on empirical data and thus are smarter and less speculative. The DBDP will be used to identify areas in which solutions deployed in the project district during the project life can be deployed in other parts of the city as well as informing of the best time to deploy solutions across the city, based on accurate data on the use and success of solutions linked to their specific building type, socio-demographic conditions, geographic conditions, and so on. The DBDP is explained fully in T3.6.1.

The feed of data from the project interventions into the DBDP permits the recording of detailed performance metrics which, when combined with project management information retained by Glasgow City Council in its role as WP coordinator, will be used to compile an inventory of progress providing detailed information for future delivery in other areas in the city, as well as providing a repository of information of high value to follower cities wishing to replicate the interventions in their city.

1.3 Solution Location

The DBDP is available to users at the following location:

https://databased.site

This link is available to users both within and external to GCC.

1.4 Demonstration Video

A demonstration video has been created to show the operation of the tool. The 2 Use Cases discussed later in the document are illustrated in the video.

The video can be downloaded from the following location:

DBDP Video

2 Solution Developed

2.1 Assessment of Existing Technology Options

To ensure that a tool was not developed that already existed on the market, significant research was carried out to understand what was available. Details of this assessment process are found Appendix A1.

In summary, there were found to be some tools, which had functionality close to that required, but none were able to be deployed easily within the GCC corporate IT environment. Furthermore, to ensure the solution developed has a legacy within the council, the tool had to align with the existing GIS product suite and data environment. Many of the tools identified – some of which were open-source – would potentially have to be maintained in-house after the RUGGEDISED project finishes. Experience from the Future City Glasgow project has shown that any significant legacy requirement to support software solutions is likely to result in the software not be used once the project is finished, therefore solutions of this nature were avoided.

2.2 Accessing the DBDP

User can access the tool via the link:

https://databased.site

Users will be presented with a login screen that looks as follows:

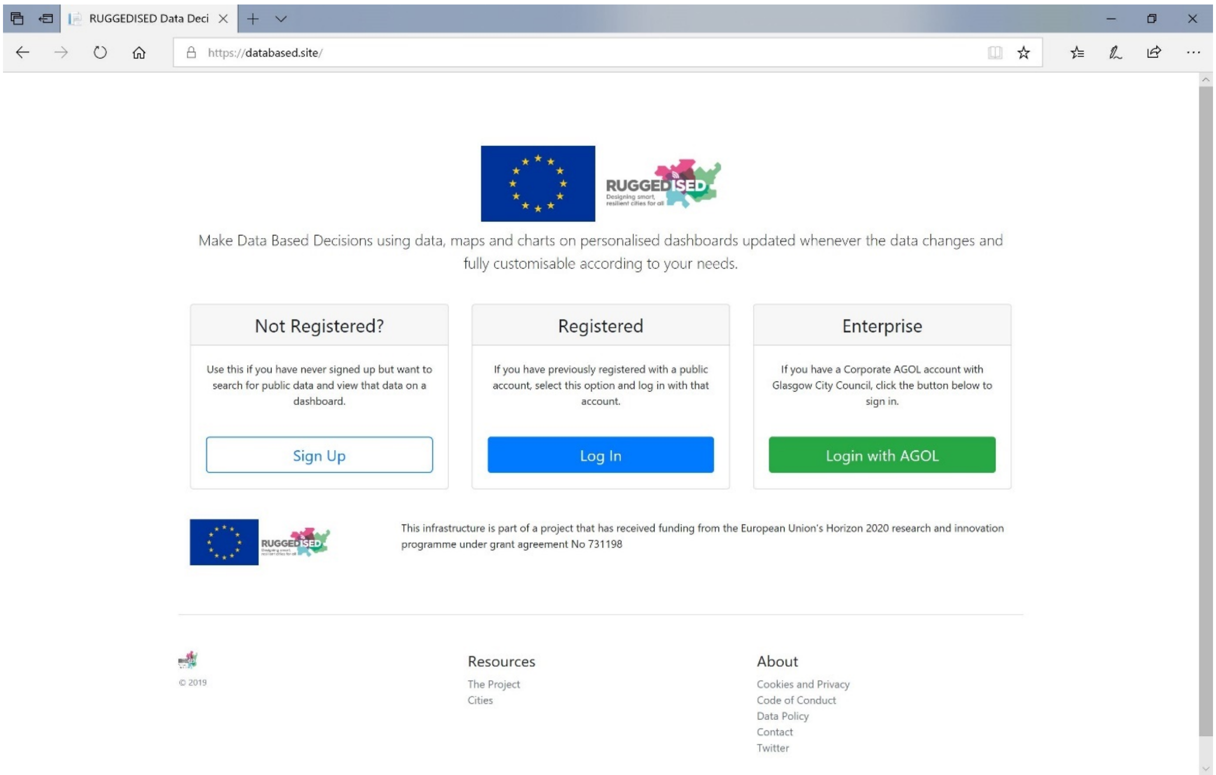


Figure 1. DBDP / AGOL Login

Users have 3 options available to them:

1. Sign up to the Platform if they have not already [button on left-hand side]
2. Login with their existing credentials [middle button]
3. Login with their ArcGIS Online (AGOL) credentials [right-hand side button]

2.2.1 Registered User Login

Users that do not have access to AGOL simply register with the DBDP, after which they can login as 'Registered' users. This gives them access to all the publicly available datasets discussed later in the report and to overlay with other datasets they may have access to.

The DBDP has been written using the ESRI Software Development Kit (SDK), so it can load in all the AGOL layers as if it were AGOL itself, but without the need for the attendant license costs.

When users click 'Log In' they will be presented with the following screen.

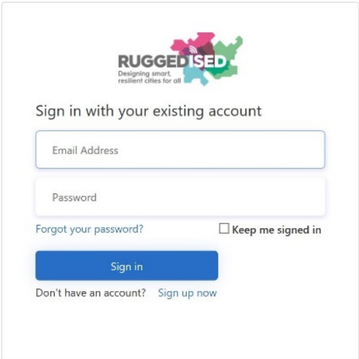


Figure 2. Registered User Log In Screen

Users then simply enter their credentials and proceed using the tool.

2.2.2 ArcGIS Login

Users that have access to an ArcGIS Online (AGOL) account can login with their credentials and this will provide them with access to the layers available on that Platform. Note that users can login with any AGOL account, not just a GCC one.

AGOL provides access to a great number of datasets, all of which are controlled via permissions set by GIS administrators. Therefore, users with access to sensitive internal data can overlay this with any other dataset they wish – internal or external – for subsequent analysis, but this data will not be made available to users that do not have the same permissions.

When users click 'Login with AGOL' they will be presented with the following screen.

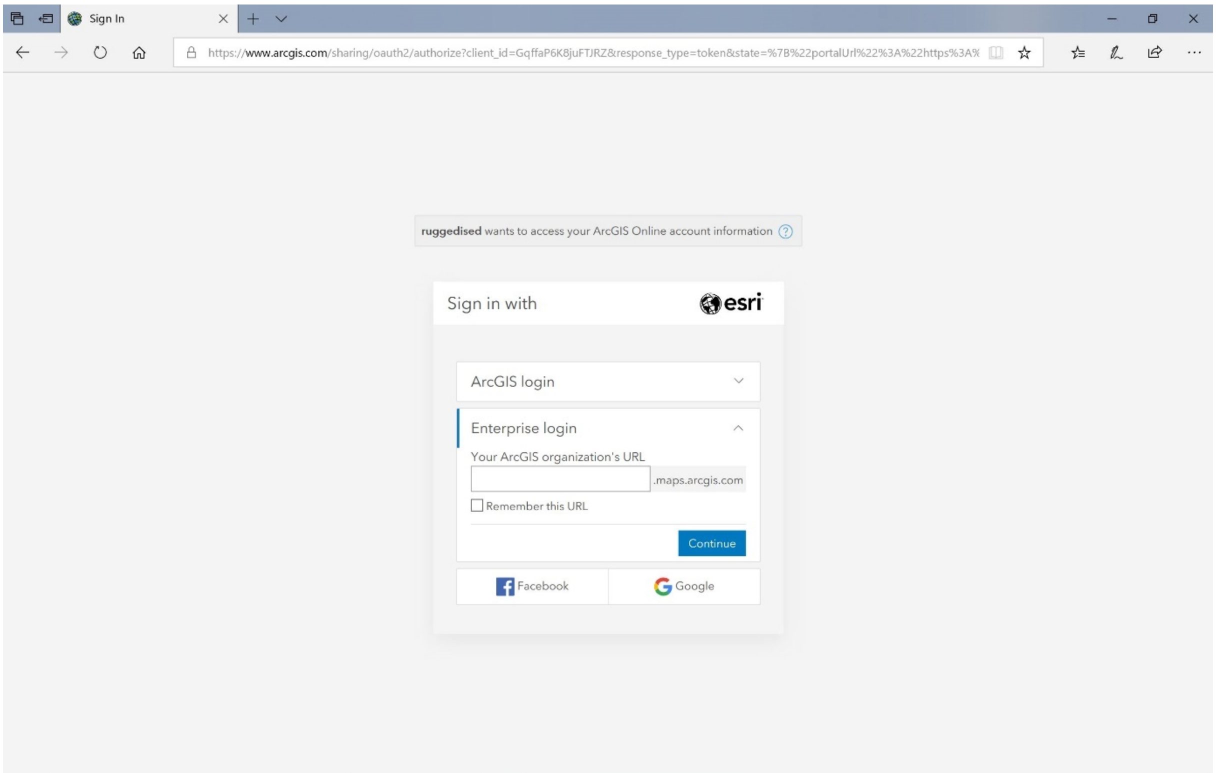


Figure 3. DBDP AGOL Enterprise Login

The default login option the Enterprise Login, which are accounts connected to a particular organisation (i.e. Glasgow City Council). Individuals users, however, are also able to sign in via their personal account by clicking on 'ArcGIS login' and they will be presented with following screen.

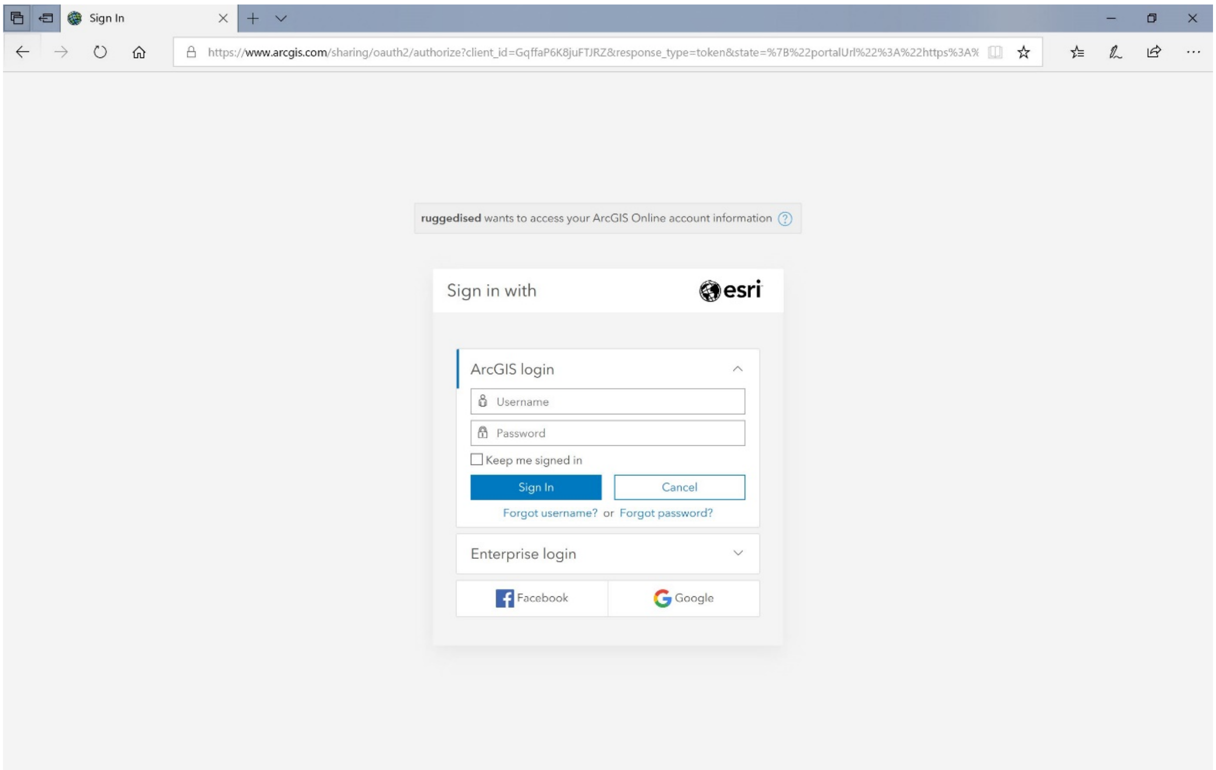


Figure 4. DBDP AGOL ArcGIS Login

Once logged in, via either means, the user will be presented with the following screen.

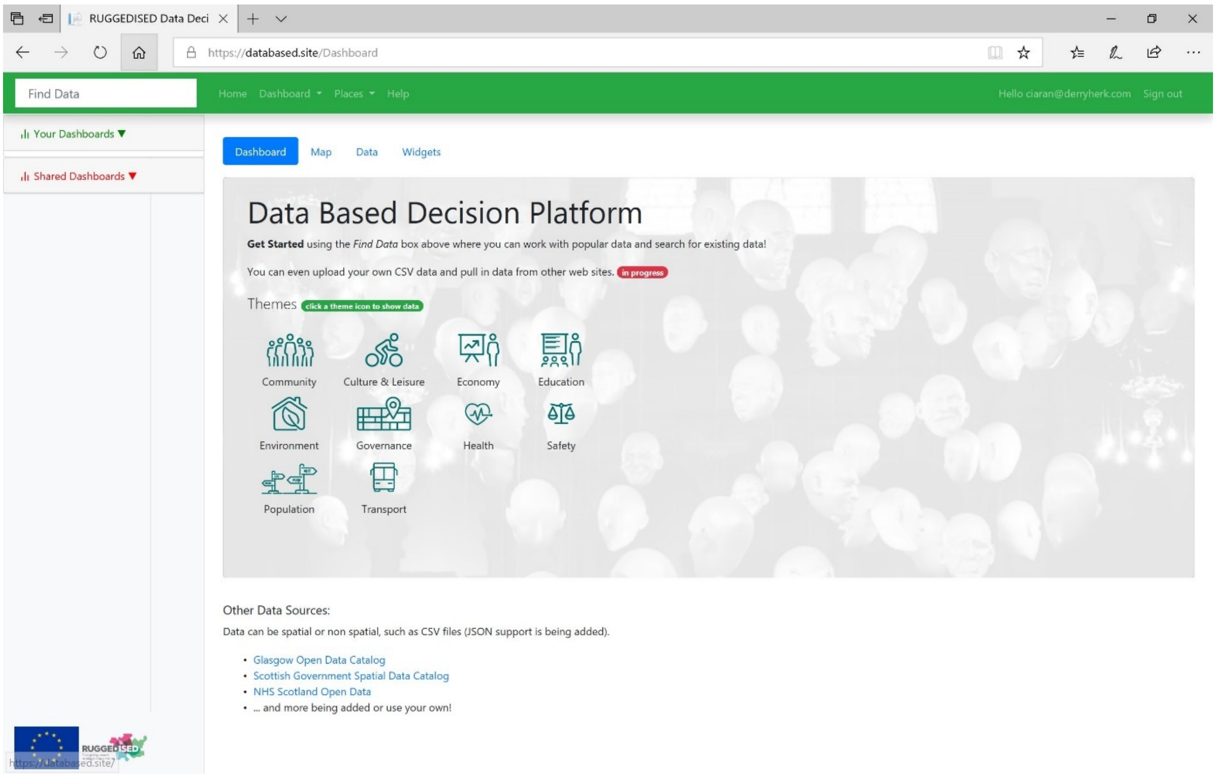


Figure 5. DBDP Post Login Screen

This is known as the Dashboard View, which is discussed in Section 2.2.7 below.

Before any dashboards can be created, data must be loaded into the DBDP. This is now discussed.

2.2.3 Adding Datasets/Layers

To add data to the DBDP, users simply click the 'Find Data' box in the top-left of the screen and they will be presented with the following pop-up window.

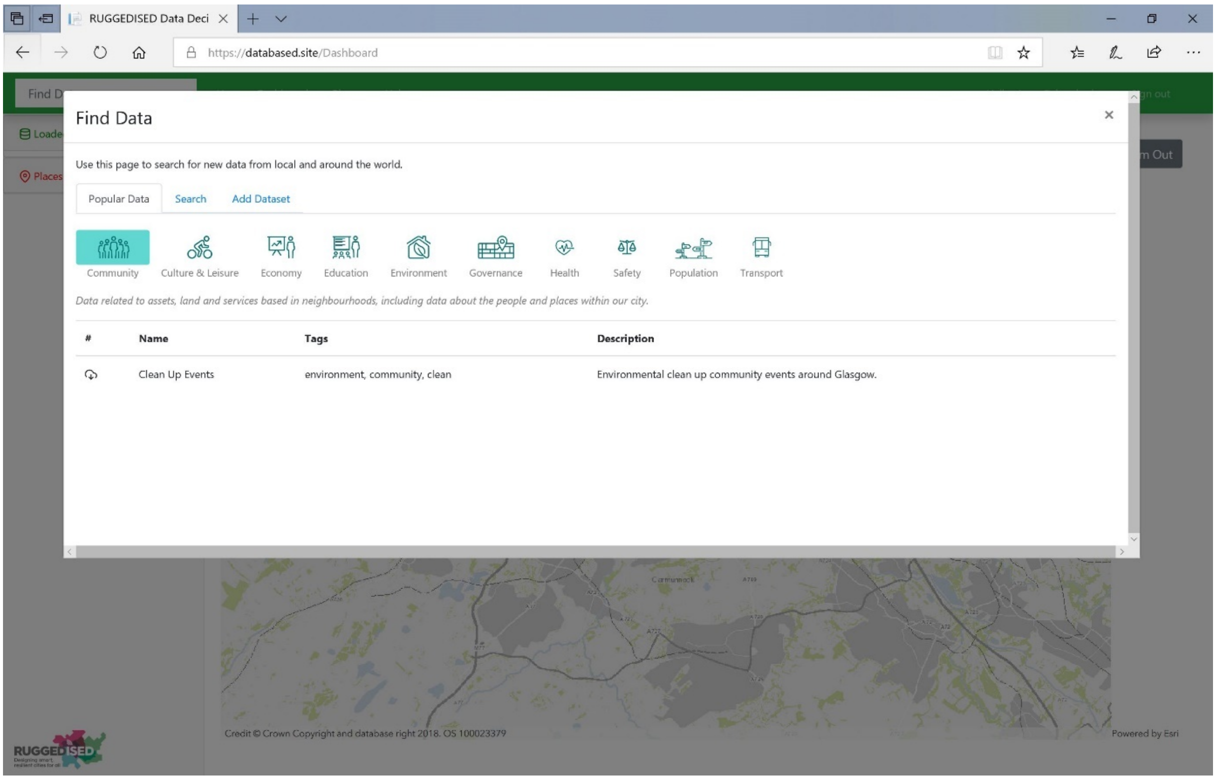


Figure 6. DBDP Add Data Window

From here the user has 3 options that can be chosen by selecting the associated tab:

1. Search for data. This is data that is available to the user on AGOL. What is available to each user will depend on the permissions they have within AGOL to various datasets.
2. Select one (or many) of the popular datasets that are available to all AGOL users.
3. Add a dataset known to the user. This can either be an internal or external dataset and can be of a range of formats (discussed later).

Each of these options is now discussed in detail.

2.2.3.1 Searching for data

To search for datasets, simply type a keyword in the 'Find Data' box in the pop-up window and all datasets that have this word either in their title or as a metadata tag will be presented. If the screen is left blank, all datasets will be presented.

By default, only datasets from Glasgow City Council (GCC) are presented, however, the user can select to search across a range of organisations:

- Glasgow City Council
- SP Energy Networks (RUGGEDISED partner)
- Scottish Water (public sector organisation)
- European Commission
- The World (all organisations that have an AGOL account)

The scope of the search can be changed using the drop-down menu to the left of the 'Search Data' button, illustrated in Figure 7 below.

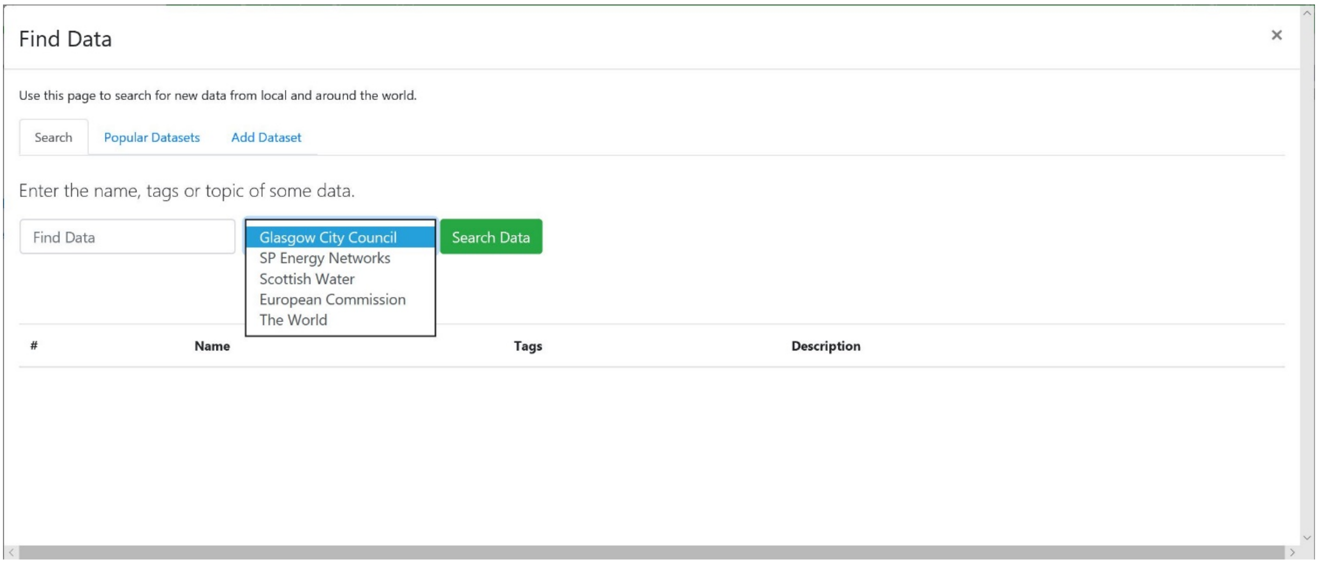


Figure 7. DBDP Selecting Scope of Search

Only datasets that have been made public will be available to external users. If, however, the user has a login with additional privileges, more datasets will be presented.

When the search term has been input, the search is executed by clicking on the 'Search Data' button. All datasets that are relevant to the search are then presented, illustrated in Figure 8 below.

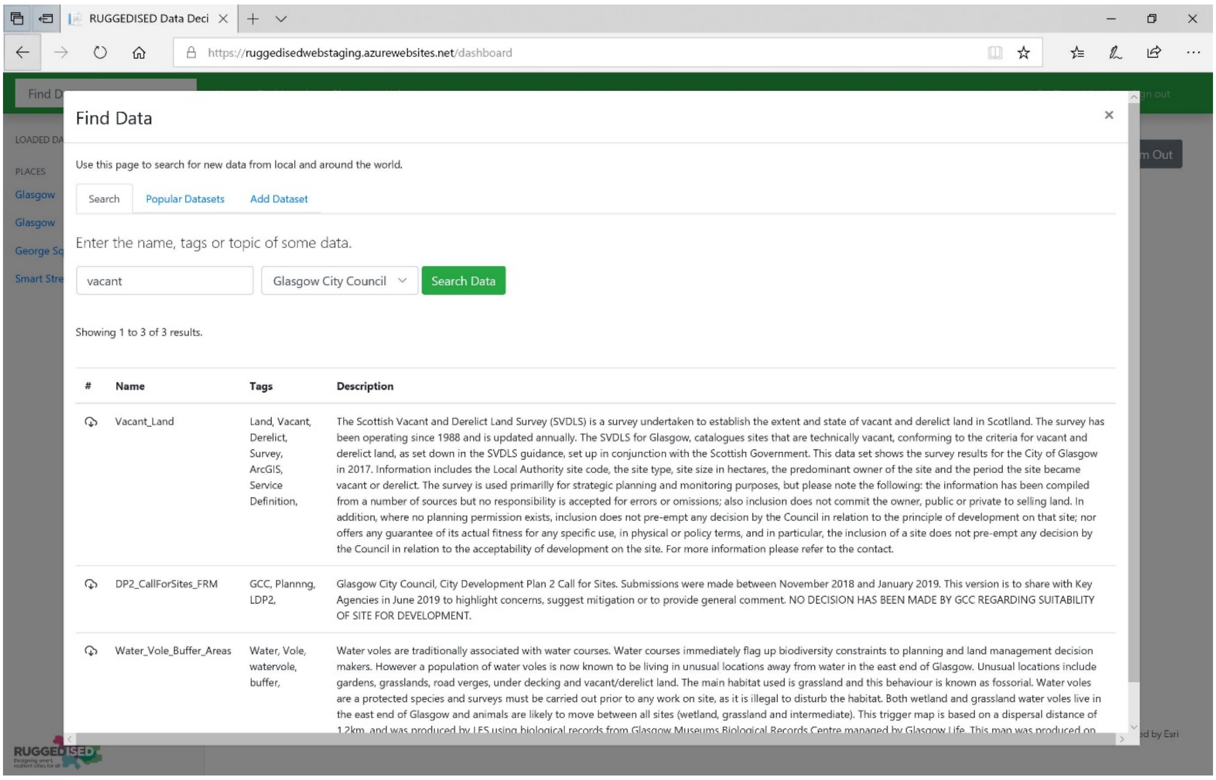


Figure 8. DBDP Search Output

When the correct dataset has been found, it can be added to the DBDP by simply clicking on the cloud-like symbol to the far left of the layer, illustrated in Figure 9 below by the large green arrow.

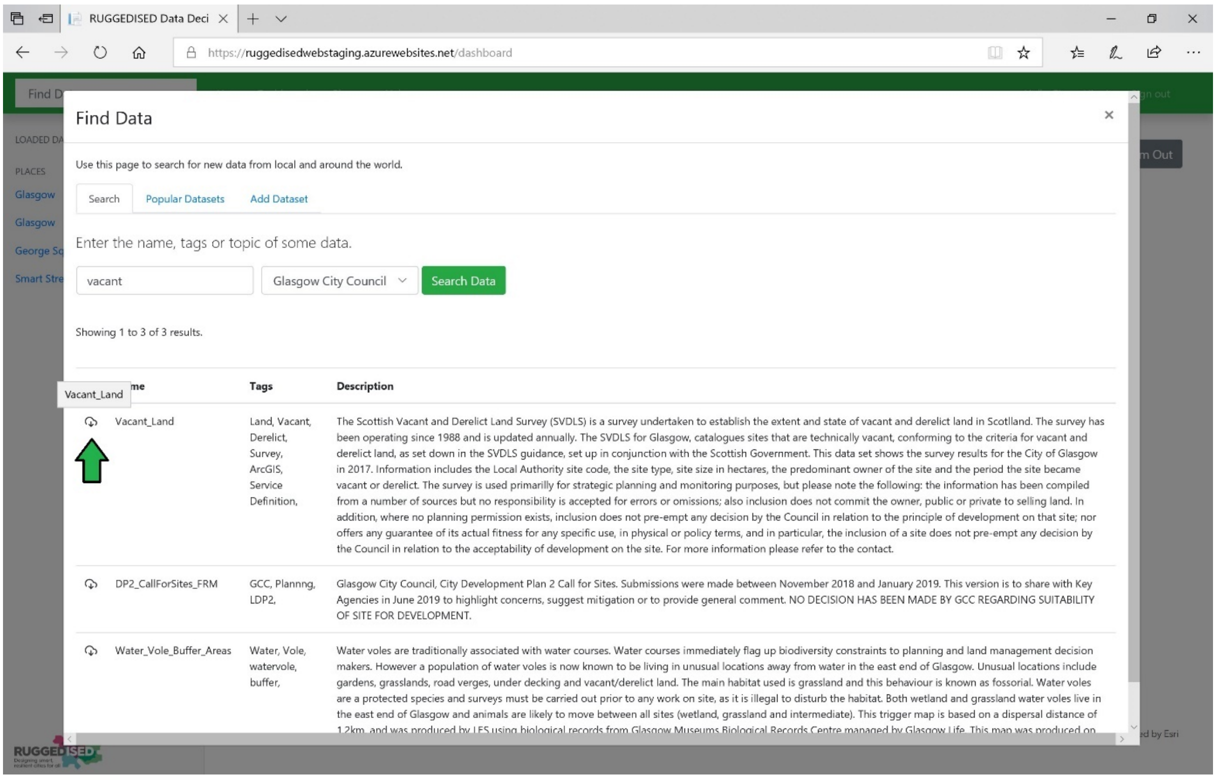


Figure 9. DBDP Adding Layer from Search

Once clicked, the user is free to search as many layers as they wish, all of which can be added to the DBDP. When all layers have been added, simply close the 'Find Data' pop-up window and the user will be brought back to a large map onto which the datasets can be added, henceforth referred to as the Map View. The Map View is discussed in more detail in Section 2.2.4 below.

2.2.3.2 Selecting popular datasets

Popular datasets have been selected by key GIS users as being useful across for a range of analysis and visualisations. When the Popular Datasets tab is selected, users are presented with dataset themes that, when clicked, filter the datasets to show only those that pertain to that theme. The themes are as follows:

- Community
- Culture & Leisure
- Economy
- Education
- Environment
- Governance
- Health
- Safety
- Population
- Transport

Each dataset can be added by clicking on the cloud-like symbol to the far left of the layer, as illustrated in the previous figure.

It is intended that the list will be auto-generated in the future, perhaps based on the number of users that are accessing each layer, but at the time of writing this remains a fixed list based on metadata tagging within AGOL.

2.2.3.3 Adding datasets

Datasets outwith AGOL can also be added to the DBDP by clicking on the ‘Add Dataset’ tab. When selected, the user will be presented with the following view.

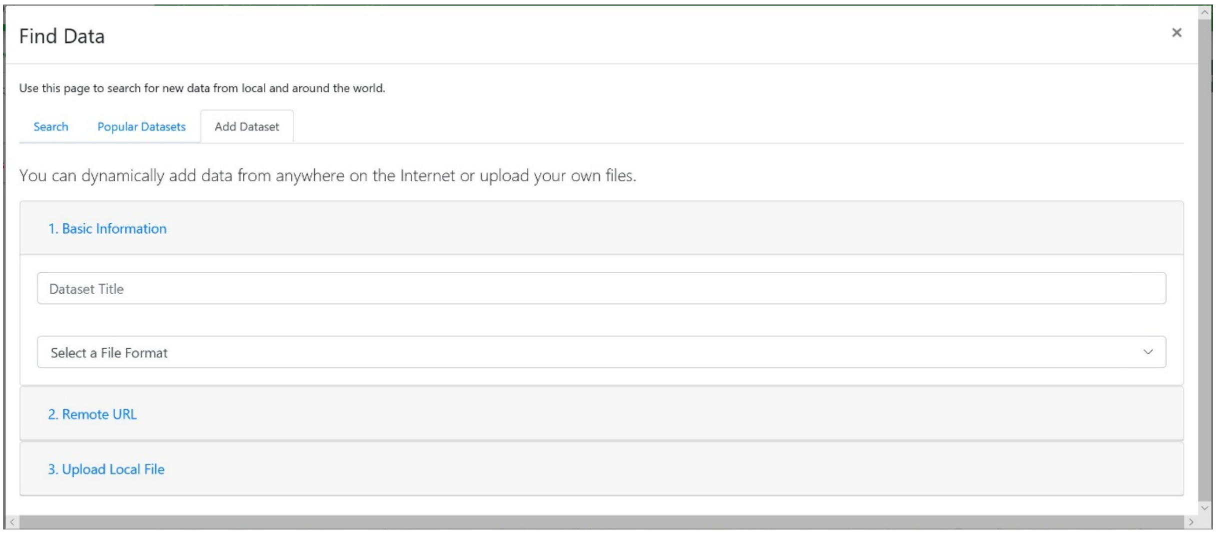


Figure 10. DBDP Adding Datasets

Users are free to either reference the URL for an API endpoint or they can load local files.

The user must provide a name for the added dataset, the path to it (i.e. the API endpoint or the file path) and the file format. The formats currently supported by the DBDP are:

- CSV (with lat/lon coordinates)
- Map Layer (ESRI)
- GeoJSON
- Geo RSS
- KML / KMZ

The format is selected by clicking on the drop-down menu entitled ‘Select a File Format’ and selecting the appropriate format, illustrated in Figure 11 below.

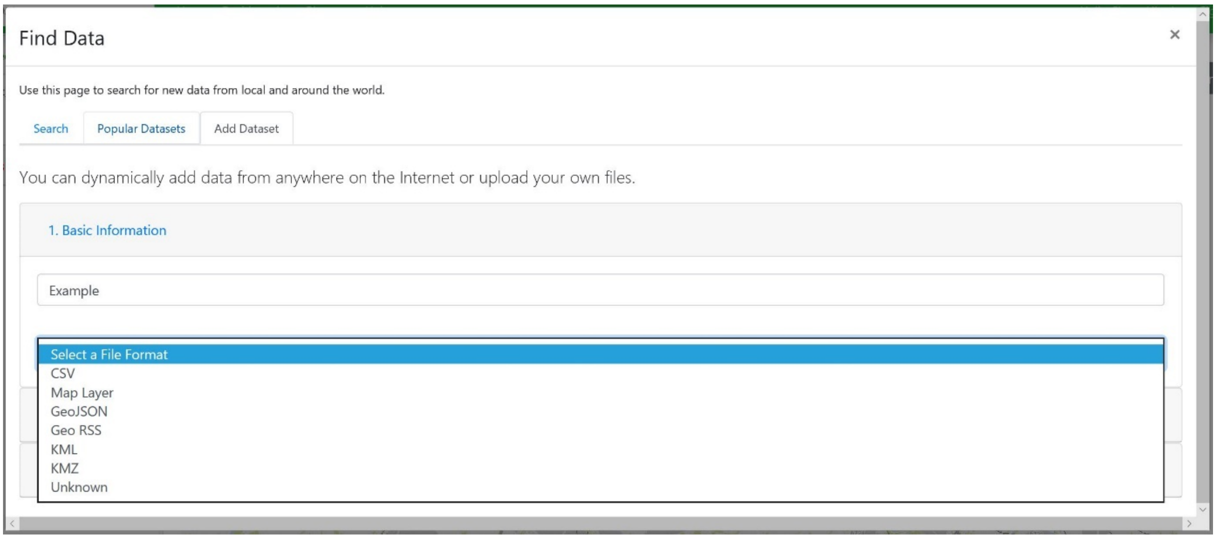


Figure 11. DBDP Adding Datasets – Supported Formats

When the dataset details have been entered, they are added by clicking ‘Add’ which in turn overlays the data onto the Map View.

To analyse the datasets added to the DBDP, they can be viewed in the following ways:

- Map View;
- Chart View; or
- Data View

These are now discussed.

2.2.4 Map View

To navigate to the Map View, simply click on the map button, illustrated by the green arrow in the figure below.

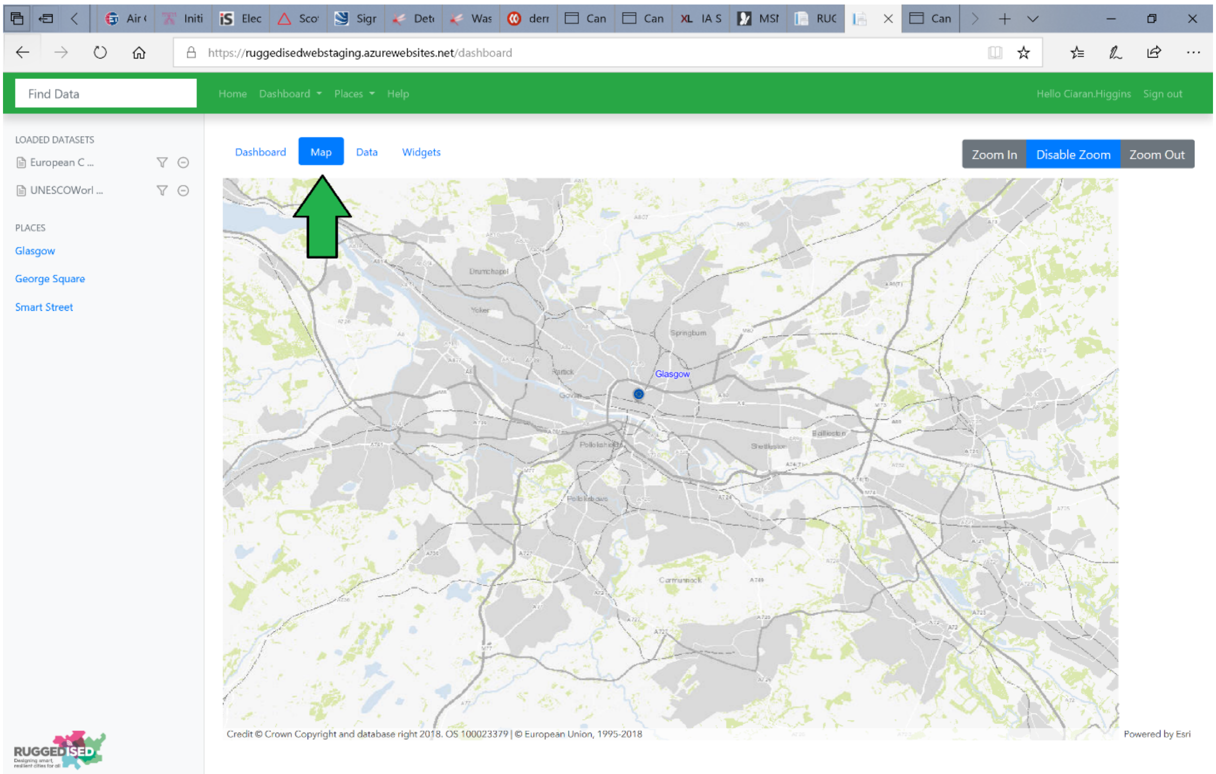


Figure 12. DBDP Map View Selection

Once in the Map View, to add the layers to the map, simply click on the ‘+’ sign to the right of each dataset listed on the left-hand side of the map and the layer will appear on the map. The location of the ‘+’ sign is illustrated in Figure 13 below by the green arrow. The figure also shows the added layer on the map.

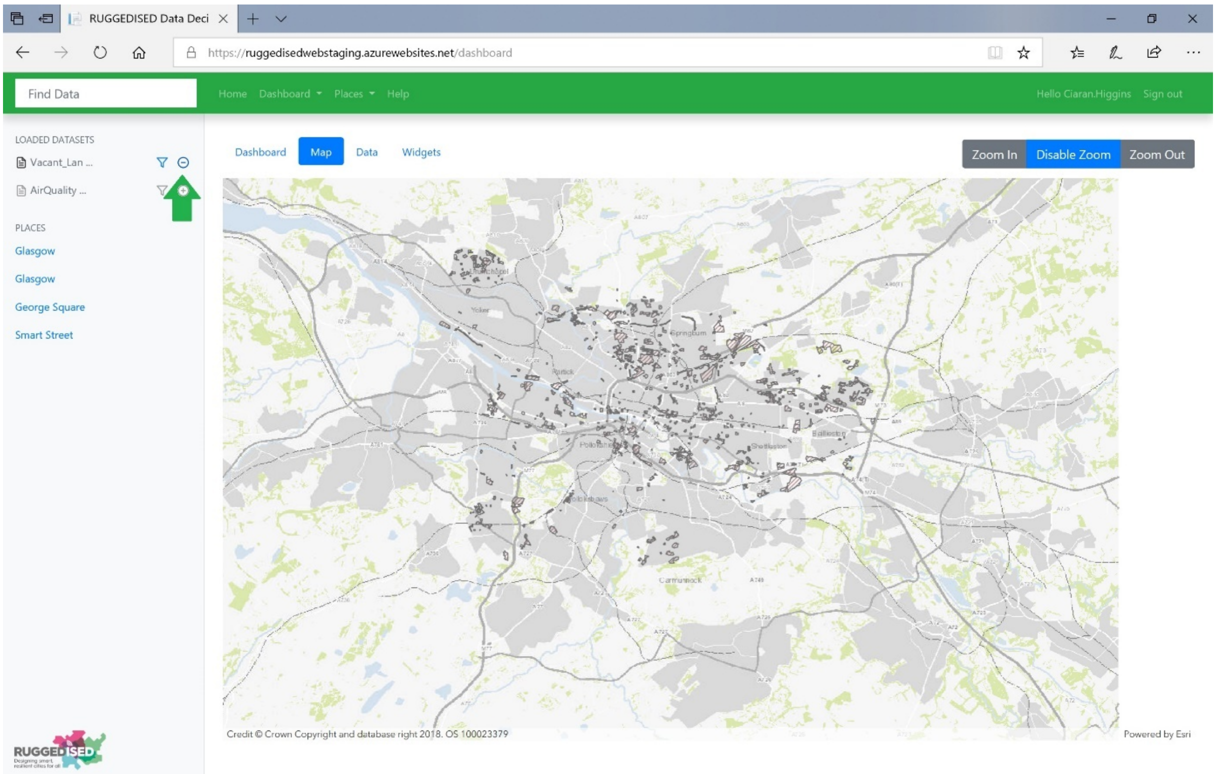


Figure 13. DBDP Adding Layer onto Map

Note that the default extent of the map is Glasgow and this is projected to 'British National Grid' (EPSG: 27700), but this can be changed for datasets, which are either not on this projection or in a different location altogether. This is discussed in the following section.

Once the data has been loaded onto the map, the user can zoom into specific areas and select features, which in turn will create a pop-up window that will show the underlying data for the feature in question. This is illustrated in Figure 14 below.

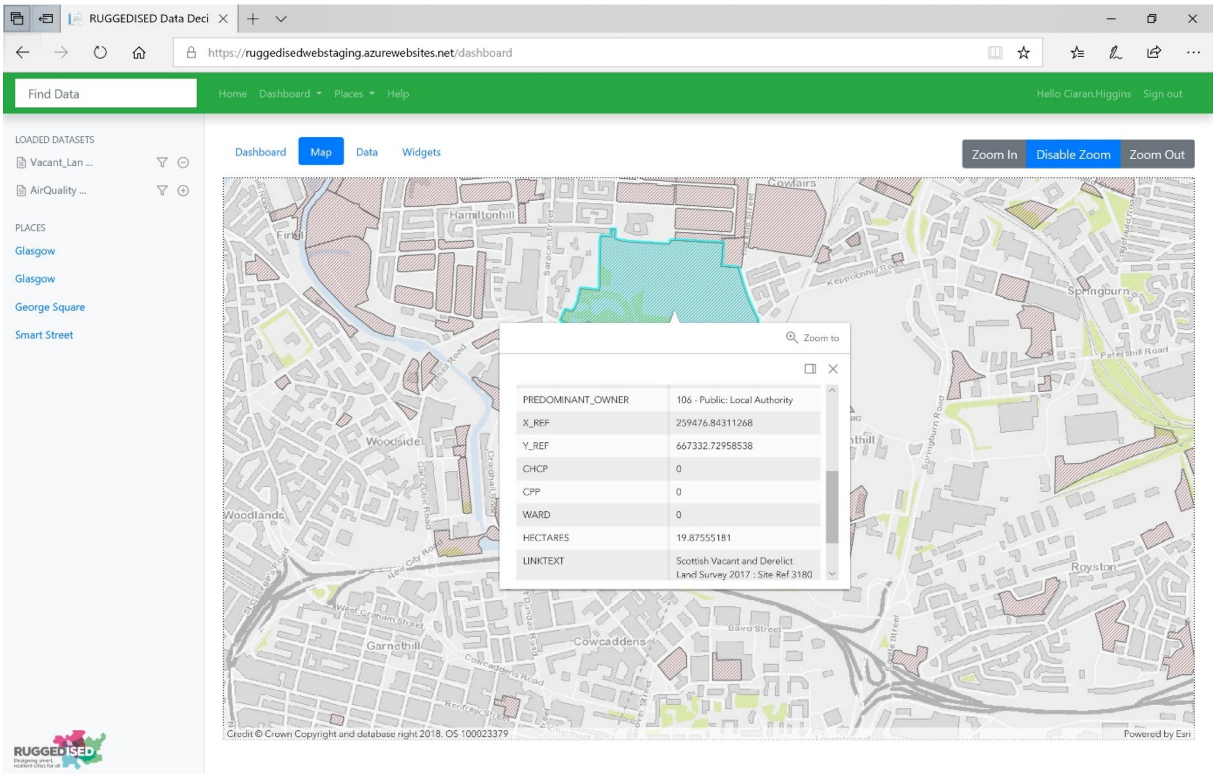


Figure 14. DBDP Selecting Feature on Map

2.2.4.1 Navigating to 'Places' across Glasgow

A number of useful map extents across Glasgow have been pre-programmed into the DBDP that changes the map extent – i.e. field of view of the map – to a number of different locations in the city. Those currently available are:

- Glasgow (the whole city)
- George Square (main square in city centre, on which City Chambers are located)
- Smart Street (RUGGEDISED project area)

These can be selected by clicking on the appropriate link under the 'PLACES' title on the left-hand side of the Map View (seen in Figure 14 above).

More 'Places' can be added in the future. For example, political ward boundaries could be added so that councillors or residents of the city are able to zoom into the area of that they represent or live in. At the time of writing, however, only those listed above are available.

2.2.4.2 Alternative Mapping Extents & Locations

Most datasets produced for Glasgow are projected to British National Grid (EPSG: 27700), as this is the projection of all Ordnance Survey (OS) datasets, but some will be projected onto a WGS 84 (EPSG: 4326) as this is the same projection as services such as Google Maps and so it is common that datasets are projected to this as it means data from across the world can be placed on the same map.

The default Glasgow map – i.e. when the Map View is opened – is the British National Grid projection. To change the basemap to WGS 84, simply click on 'Places' on the top ribbon of the DBDP and a drop-down menu of different locations / map projections will appear. This is illustrated in Figure 15 below.

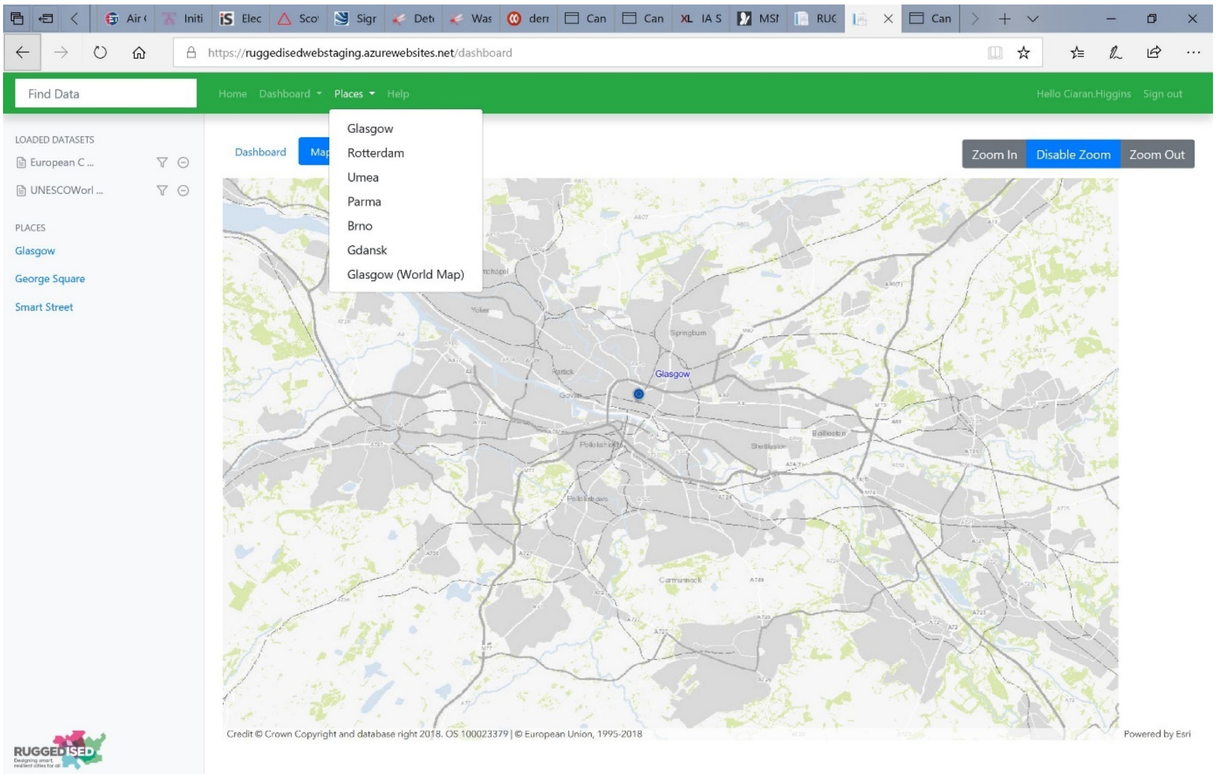


Figure 15. DBDP 'Places'

To change to WGS 84, select 'Glasgow (World Map)' and the base map will change. The RUGGEDISED partner cities have also been added as locations, to illustrate how dashboards can be created that have map widgets from a range of different locations. The different 'Places' available to the user are:

- Glasgow (BNG projection)
- Glasgow (WGS84 projection)
- Rotterdam (WGS84 projection)
- Umea (WGS84 projection)
- Parma (WGS84 projection)
- Brno (WGS84 projection)
- Gdansk (WGS84 projection)

In practical terms, these 'Places' act as geospatial bookmarks that take the user to a pre-defined extent. If, however, the user wishes to navigate elsewhere in the world, they can simply move around the map like any other online mapping utility.

2.2.5 Data View

When each layer is added to the DBDP, all the data contained within the layer is also available to the user in a raw tabular format. To navigate to the Data View, simply click on the map button, illustrated by the green arrow in the figure below.

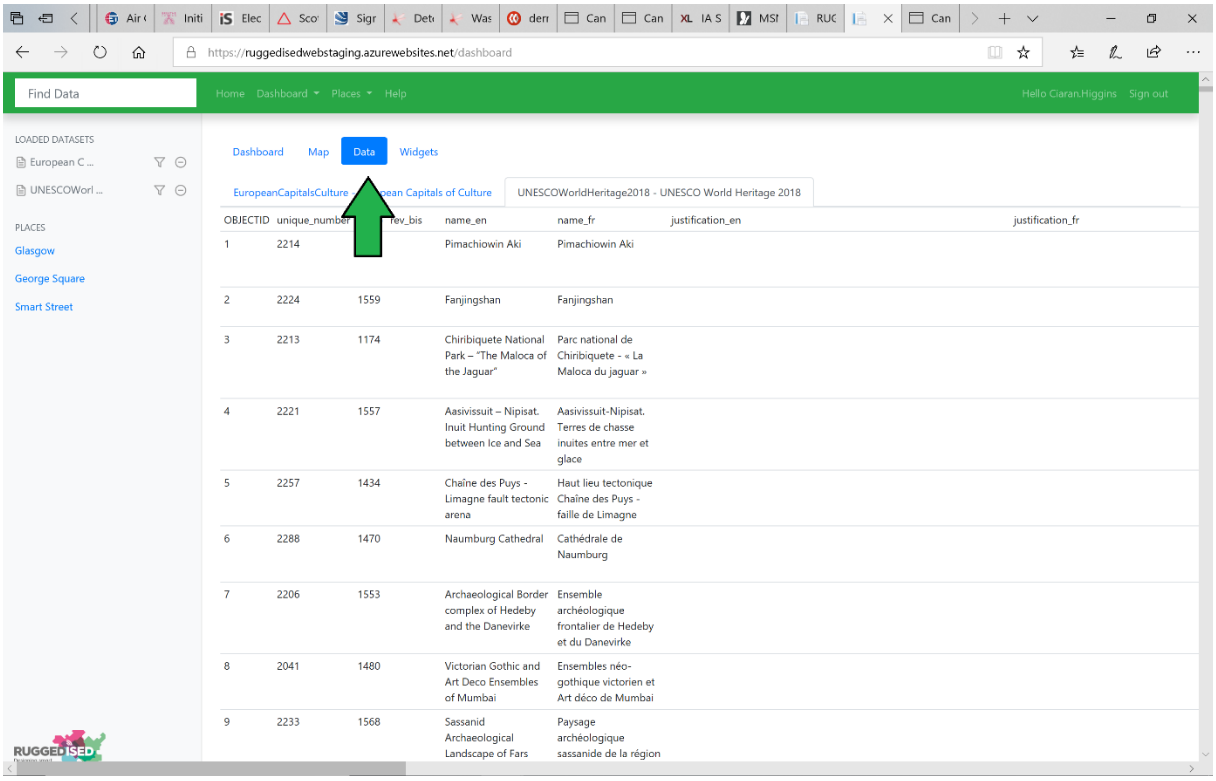


Figure 16. DBDP Data View Selection

When clicked, the data within each dataset/layer loaded into the users' view will be available for analysis. Tabs separate each dataset, so users can simply select the one they wish to analyse.

Note that only the datasets loaded into the current Dashboard are seen. Any new datasets loaded will also be available in the Data View.

2.2.5.1 Data Filtering

If the datasets are large, users may filter them so that the data presented on the DBDP is a subset of the original. To do this, simply click in the funnel icon – indicated by the large green arrow in Figure 17 below – and a SQL Data Filter box will appear, illustrated by the blue arrow.

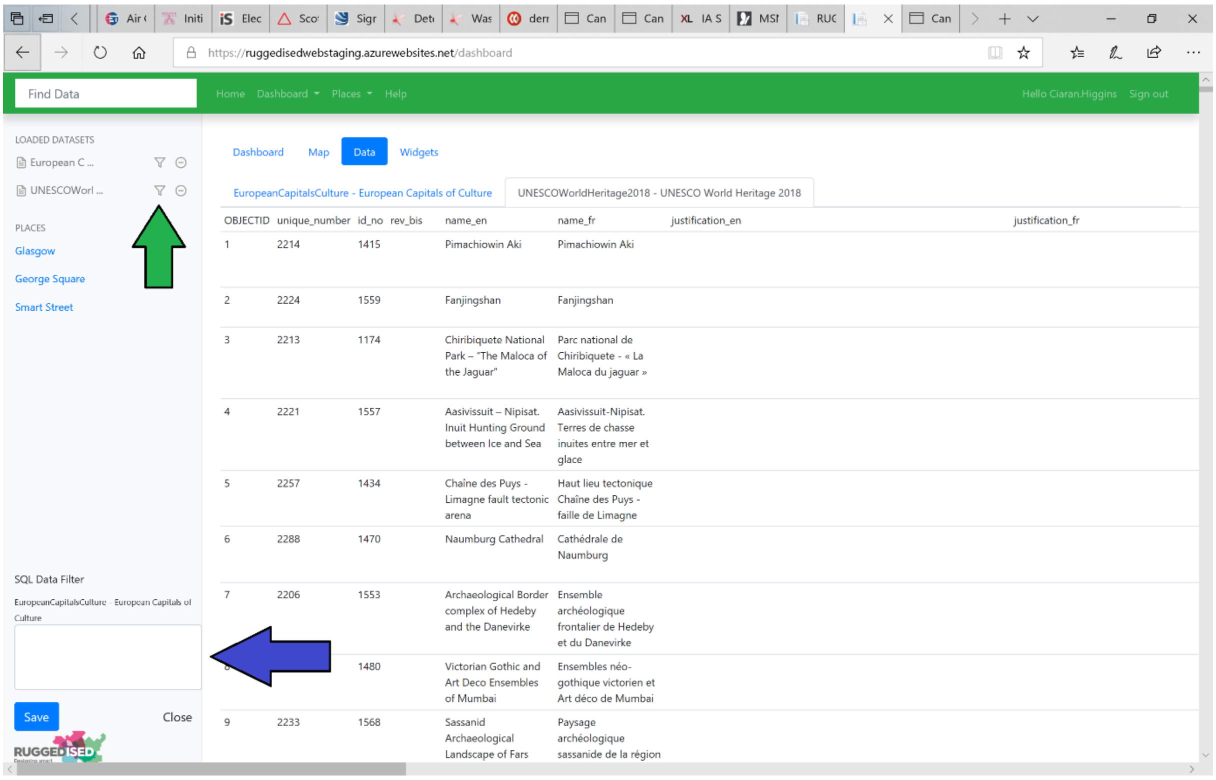


Figure 17. DBDP Data Filtering

Specific queries can then be written within the SQL Data Filter, which will filter the data appropriately. When filtered in the data view, the same filters will apply to both the Map and Chart/Widget Views.

By way of example, if a dataset has a column containing the countries, the user can filter the data to show only features that below to a particular country. See example query below:

```
"Country" = "United Kingdom"
```

This follows the format:

```
"COLUMN_NAME" = "SEARCH_TERM"
```

Once entered into the SQL Data Filter, simply click 'Save' and the filter will be applied to the data.

Wildcard queries can be also be used, an example of which is found below:

```
"Country" LIKE '%land'
```

Note that the field name is in double quotation marks, whereas the wildcard statement uses single quotation marks. Furthermore, the wildcard symbol is a percentage sign – '%' – not an asterisk as is often used in Windows, etc. Finally, rather than use an equals sign – '=' – the term 'LIKE' is used. If this is not used, the wildcard search will not resolve and no data will be returned. Please see below the output from the above query.

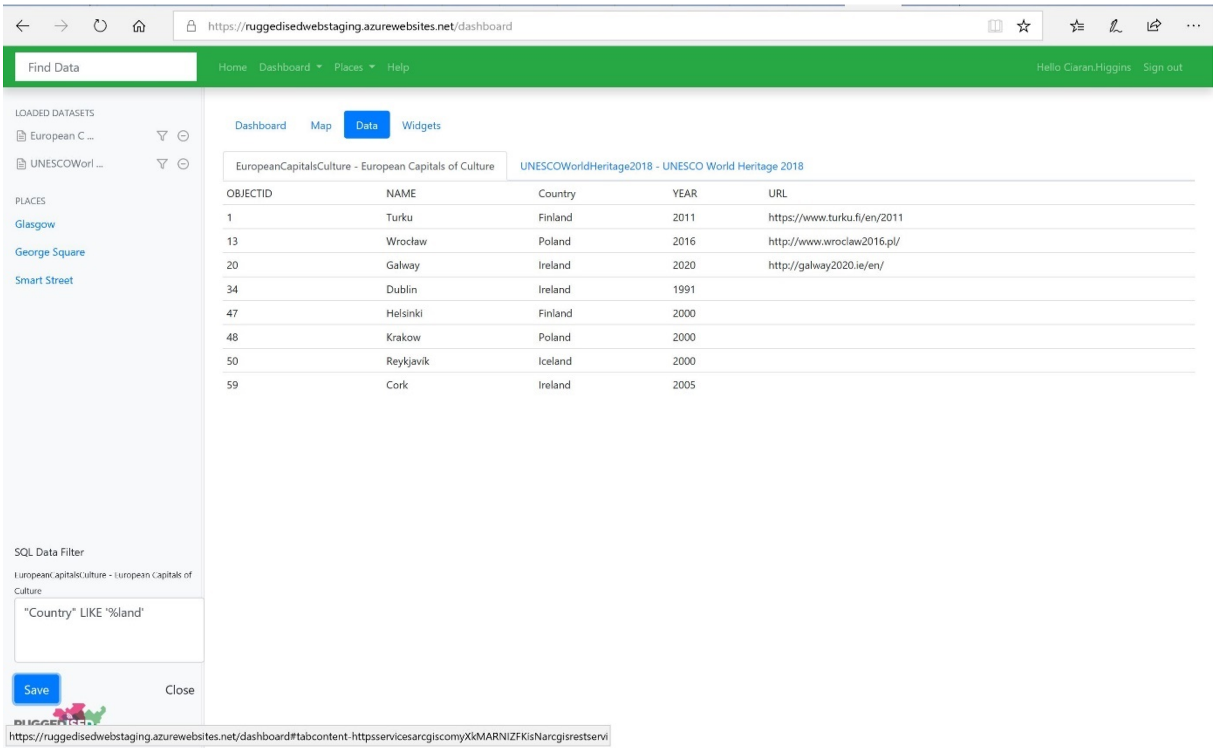


Figure 18. DBDP Example SQL Query Output

As can be seen from the results, the countries return all end in 'land': Finland; Poland; Ireland; and Iceland.

To clear any filters, simply delete the query in the SQL Data Filter and click on 'Save'.

2.2.6 Chart/Widget View

A range of charts can be created with the Chart/Widget View that can complement the maps and raw data tables. To navigate to them, simply click on the 'Widgets' button, illustrated by the green arrow in the figure below.

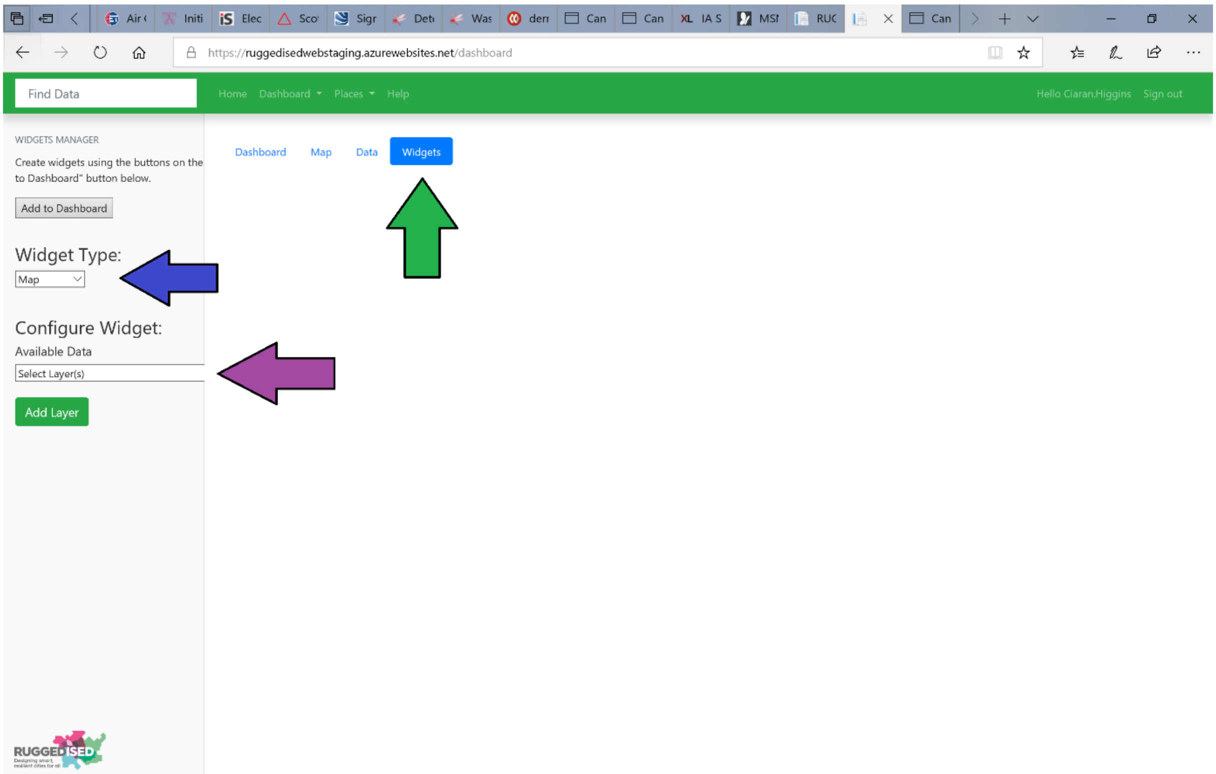


Figure 19. DBDP Chart/Widget View Selection

Within this view, several different types of widget can be created:

- Map
- Bar Chart
- Line Graph
- Radar
- Pie
- Doughnut

These are selected by clicking on the drop-down menu found under the title 'Widget Type' on the left-hand side of the screen, illustrated by the blue arrow in the figure above.

The user can select the data to apply to the widget through the drop-down menu found under the title 'Configure Widget', illustrated by the purple arrow in the figure above.

2.2.6.1 Creating a Map Widget

To create a map widget, simply select the 'Map' widget type and select the layer to add to the map from the drop-down menu under the 'Configure Widget' title. To add the selected layer to the map, simply click on the 'Add Layer' button under the drop-down menu. A map will then appear and the selected layer overlaid onto it. The user is free to select as many layers as are loaded and place onto a single map.

Once the user is happy with the map widget created, it can be added to the current dashboard by clicking the 'Add to Dashboard' button at the top-left of the screen. When this is clicked, a pop-up will appear into which the user should type the widget name/description. This is illustrated in Figure 20 below.

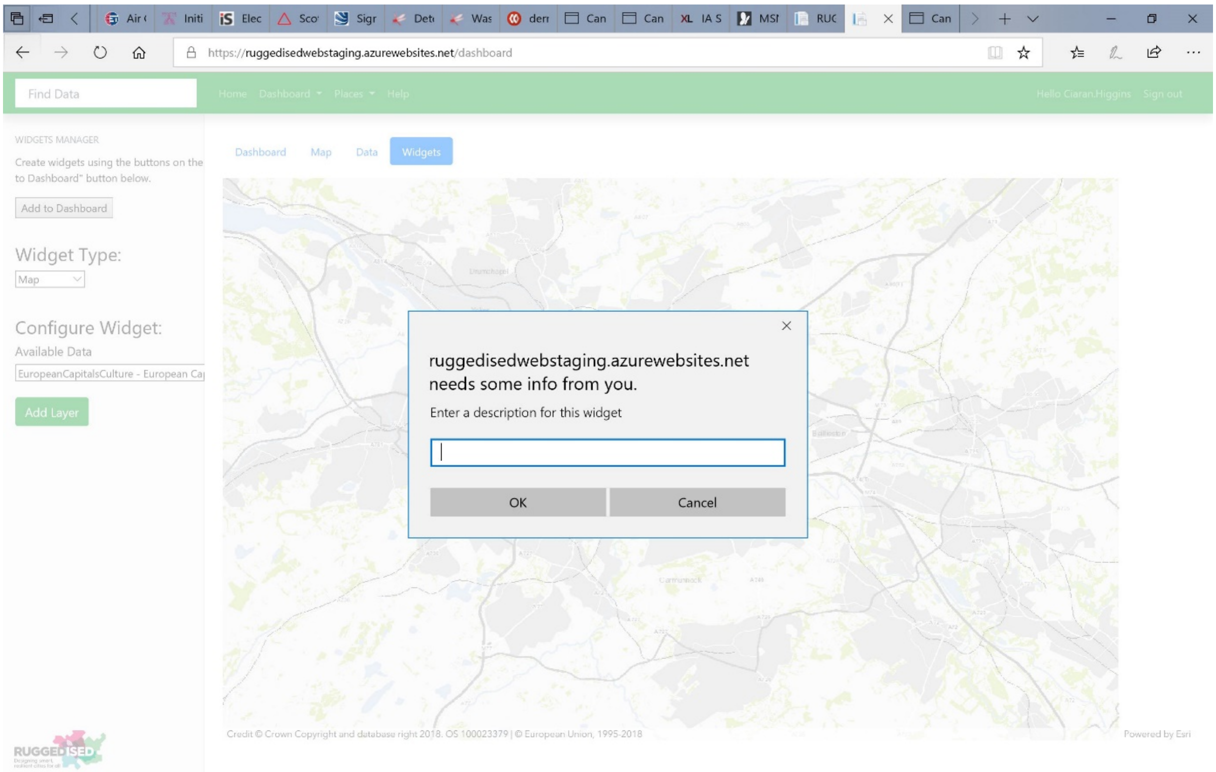


Figure 20. DBDP Adding Widget to Dashboard

Once the details have been entered, the user then clicks ‘OK’ and they will be brought to the dashboard view to view the newly created widget, as shown in Figure 21 below.

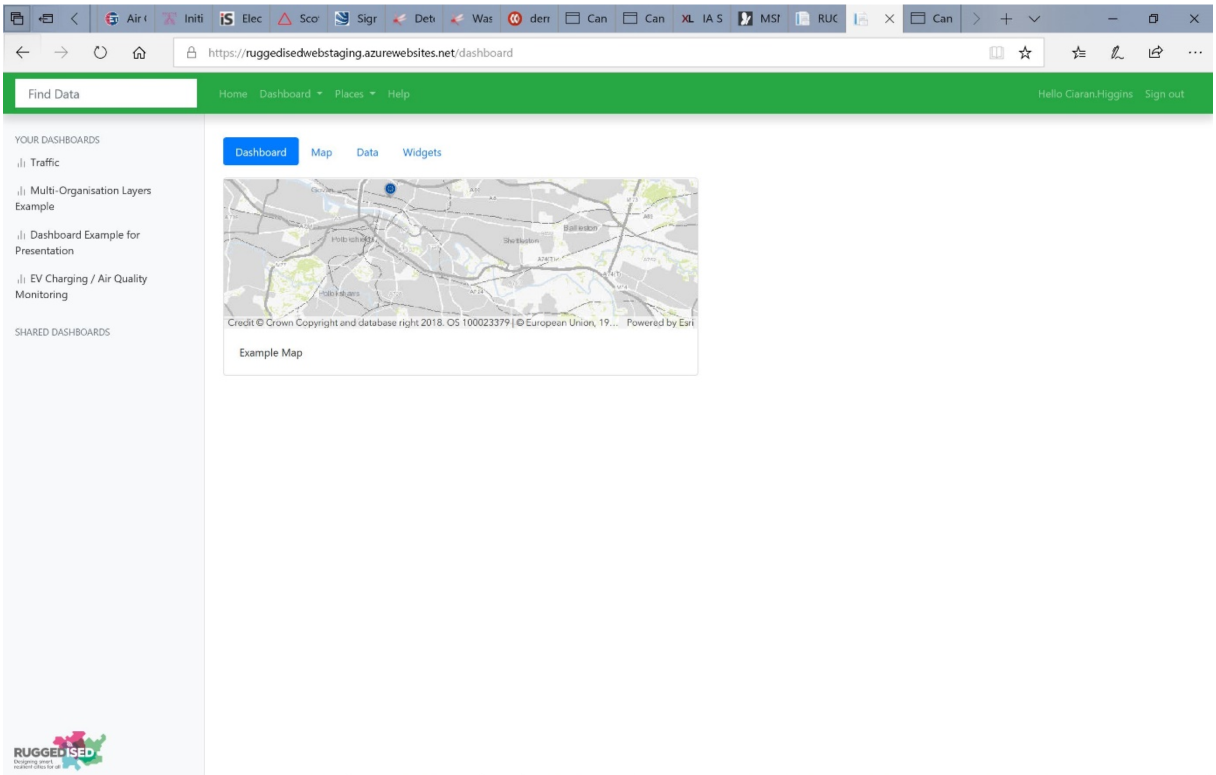


Figure 21. DBDP Example Widget on Dashboard

2.2.6.2 Creating a Chart Widget

To create a chart widget, a similar process as described above is followed, with a few exceptions. When any of the charts are selected from the drop-down menu under the title ‘Configure Widget’, additional drop-down menus appear:

- X-Axis
  - Select Dataset
  - Select Label
- Y-Axis
  - Select Dataset
  - Select Label
- Measurement
  - Select Measurement

The ‘Select Dataset’ relates to the layer that the user wishes to apply to the chart. Note that whatever dataset is selected for the X-Axis, must also be selected for the Y-Axis. The ‘Select Label’ relates to the column/field that the user wishes to display on the chart. The ‘Select Measurement’ menu has the following options:

- Each Value (plot each individual value)
- Average (plot the average of the values on the Y-Axis that have the same value on the X-Axis)
- Count (plot the number of values on the Y-Axis that have the same value on the X-Axis)
- Sum (plot the sum of the values on the Y-Axis that have the same value on the X-Axis)
- Minimum (plot the minimum of the values on the Y-Axis that have the same value on the X-Axis)
- Maximum (plot the maximum of the values on the Y-Axis that have the same value on the X-Axis)

As the user selects the different options available, the chart will update to reflect the option selected. Figure 22 below is an example plot created from the UNESCO World Heritage dataset that shows the number of sites per country across the world.

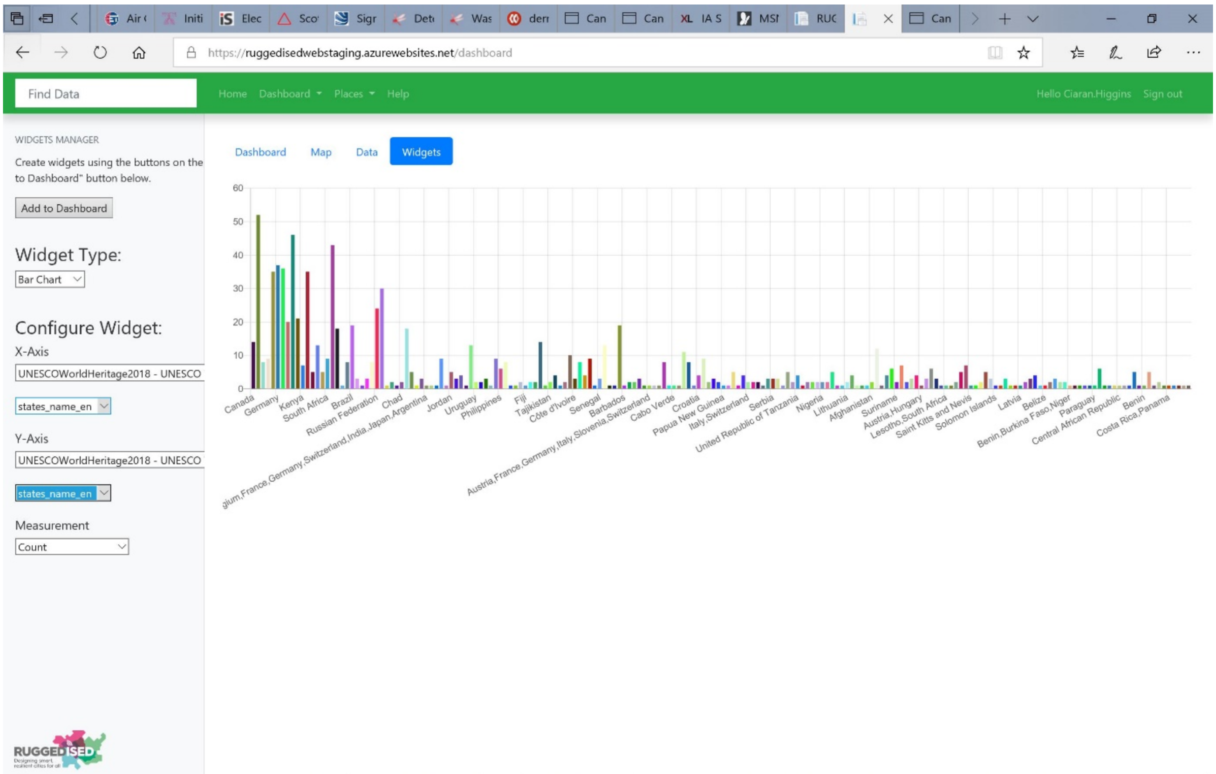


Figure 22. DBDP Example Chart Widget

To add the chart widget, simply click on 'Add to Dashboard' and provide a suitable name for the widget that will appear on the dashboard. Figure 23 shows the saved widget on the dashboard view, along with the map widget created in the previous section.

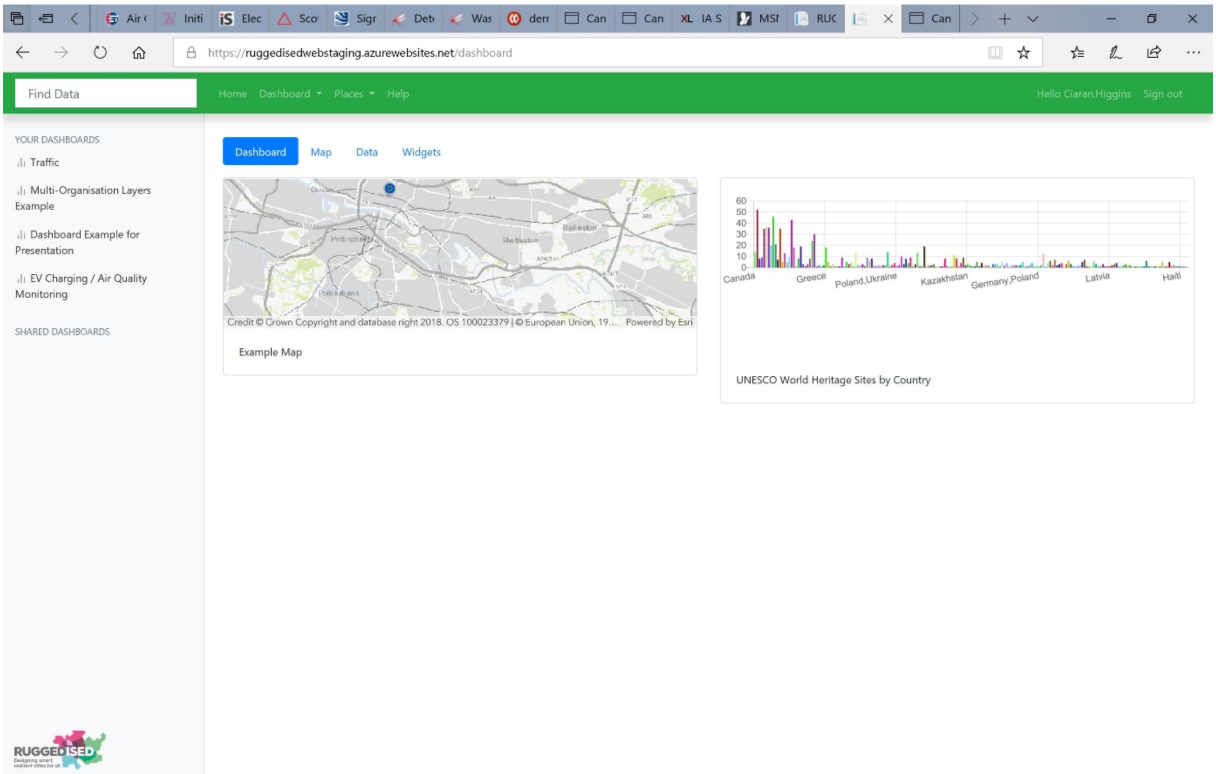


Figure 23. DBDP Dashboard View with Map & Chart Widgets

The user is free to add as many widgets as the wish to the dashboard, however for it to be simple and effective, it is not recommended to add too many.

Once the user is happy with the Dashboard created, it can be saved by clicking on 'Dashboard -> Save' at the top of the screen, illustrated in Figure 24 below.

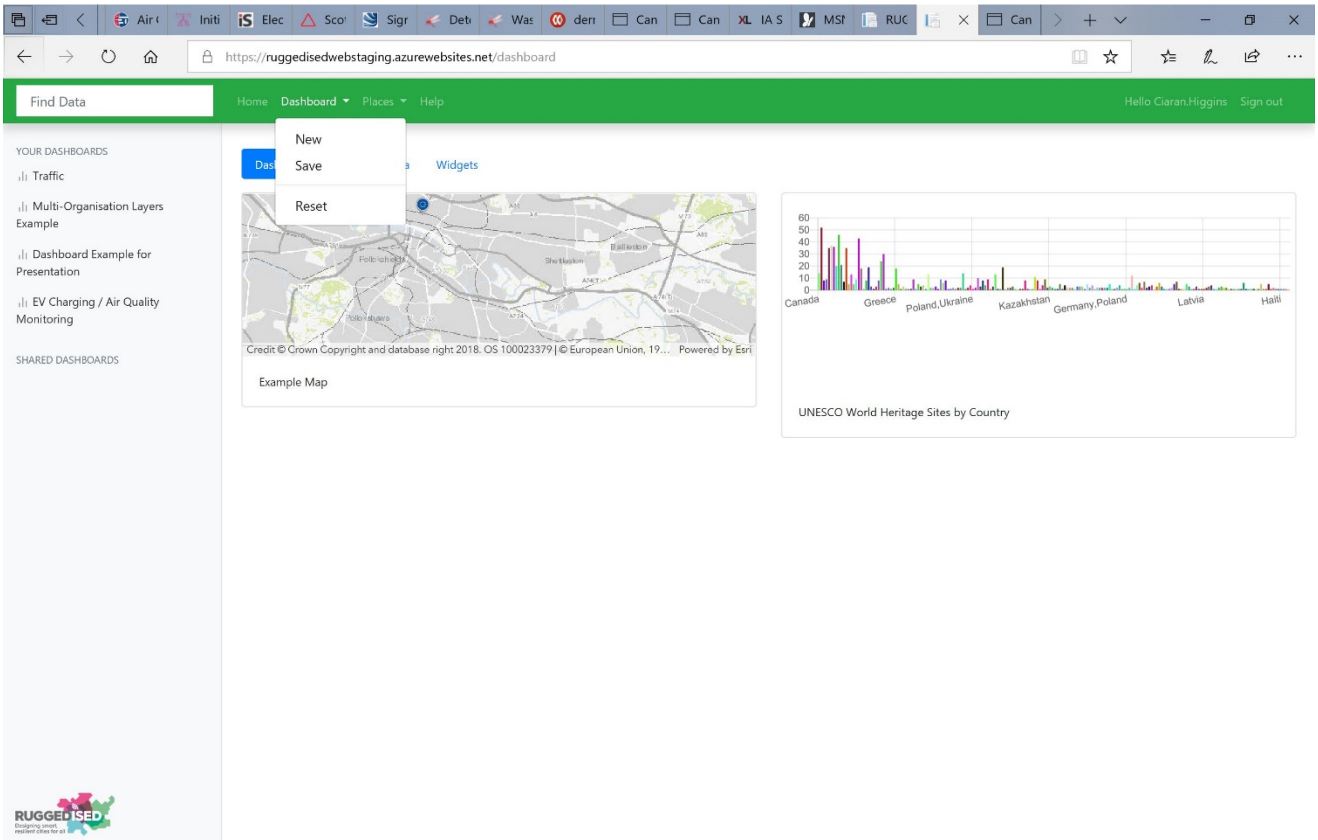


Figure 24. DBDP Saving a Dashboard

The user will then be asked to provide a name for the dashboard in the pop-up, along with a short description of its contents, which in turn will be added to the list under the 'YOUR DASHBOARDS' title on the left-hand side of the screen. This is shown in Figure 25 below.

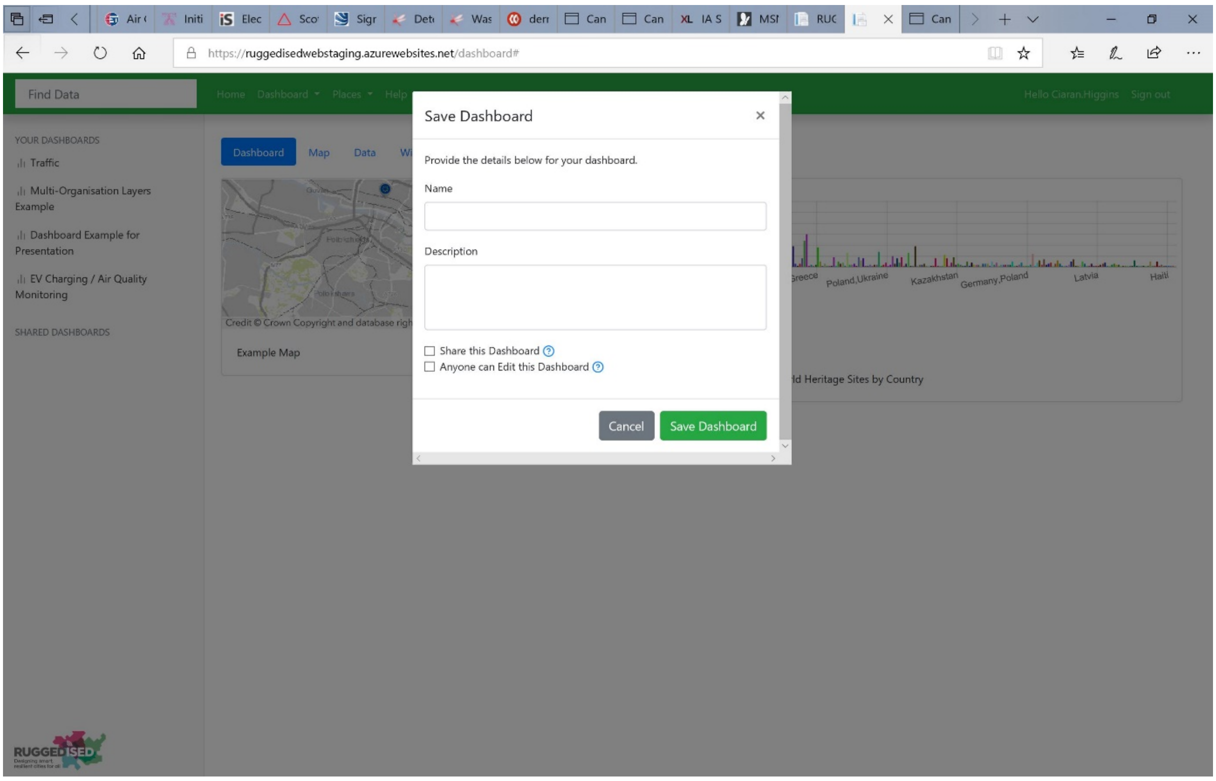


Figure 25. DBDP Naming a Newly Created Dashboard

2.2.7 Dashboard View

The first page the user is presented with when logged in is the Dashboard screen. This contains links to any dashboards the user has developed previously. This is illustrated in Figure 26 below , where 4 existing dashboards are listed under the 'Your Dashboards' title.

When an existing dashboard is selected, the last saved version of the dashboard will be brought up on the screen. Figure 26 & Figure 27 below show typical dashboards.

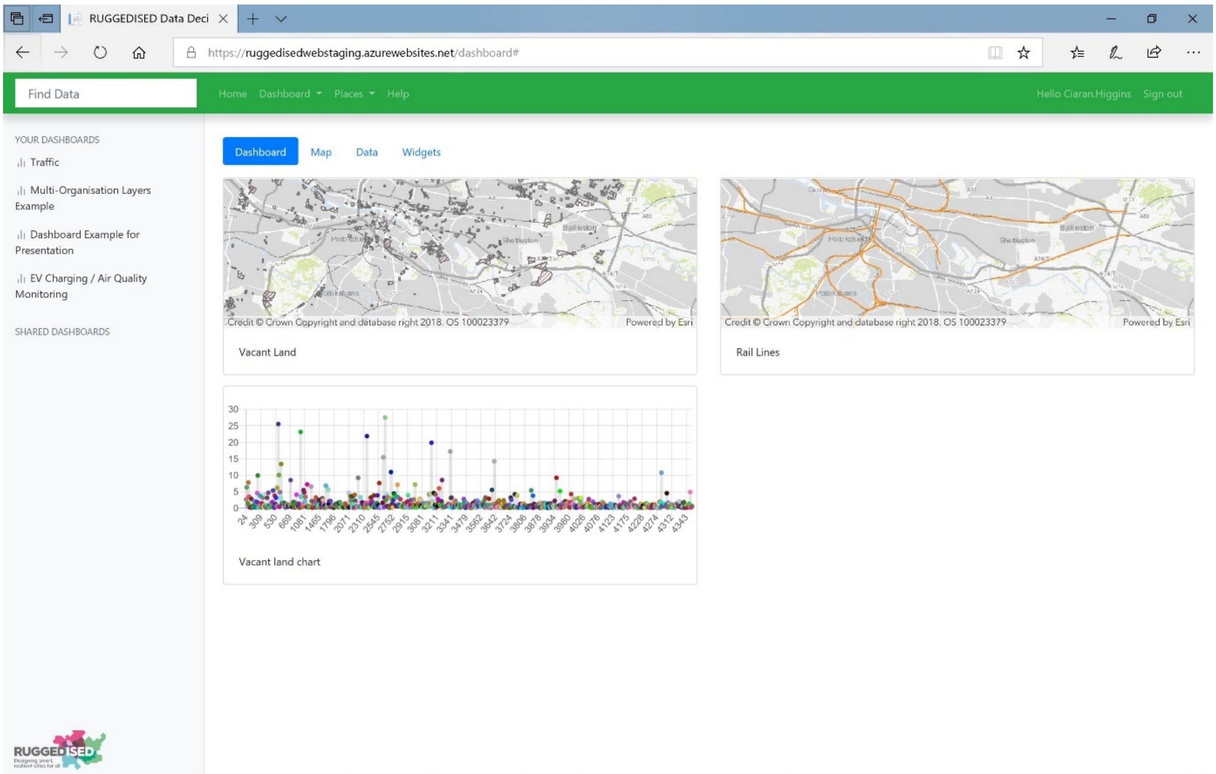


Figure 26. DBDP Dashboard Screen (I)

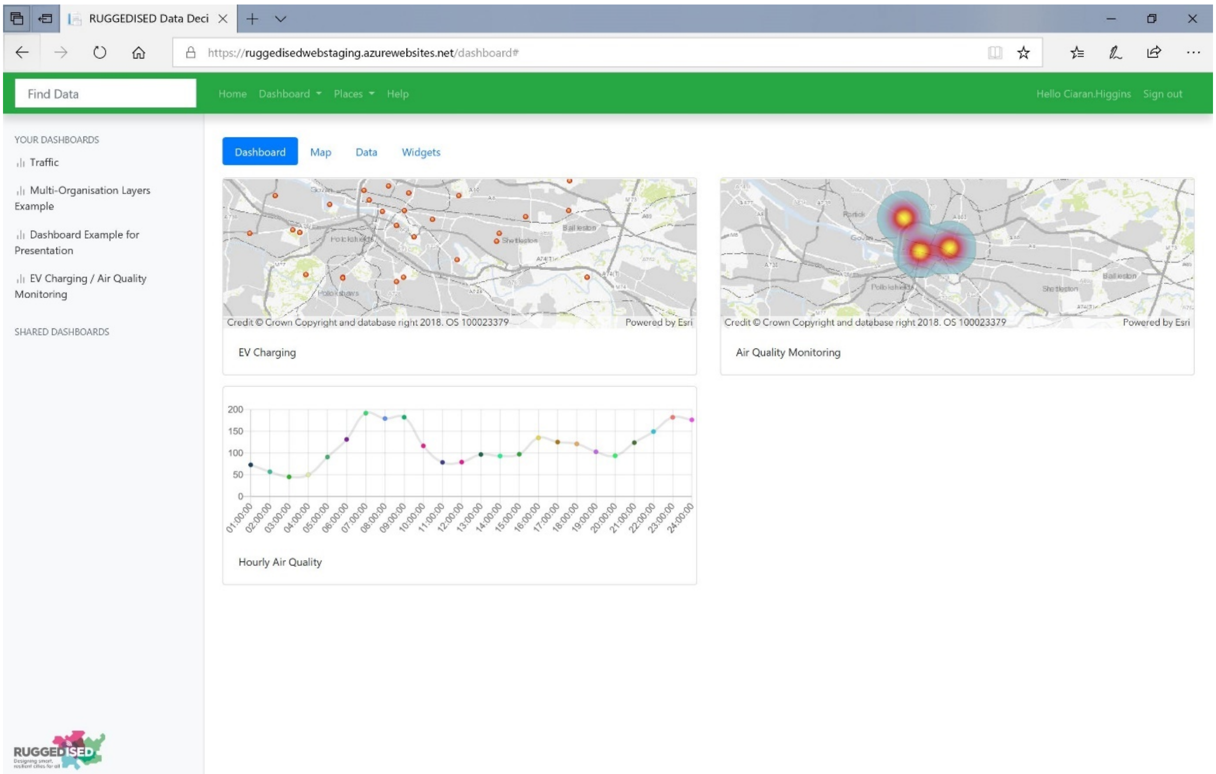


Figure 27. DBDP Dashboard Screen (II)

As illustrated, the dashboards can contain a number of different ‘widgets’ from maps through to charts, each of which has been explained in the previous section.

Each widget references either a map layer on AGOL or an external API, so every time it is opened or refreshed, any new data available will be displayed. Therefore, if a chart or map shows pollutions levels across the city in real-time, anyone accessing the dashboard will have the most up-to-date picture.

The spatial extent of each map widget is preserved, therefore if there is an area of interest that the dashboard is focussing on – the RUGGEDISED Smart Street, for example – the maps will always return to the correct extent. If, however, users wish to change the extent to another area, they can easily do so within the dashboard view and save the revised settings.

2.2.8 Creating Dashboards

To create new dashboards, simply select ‘Dashboard -> New’, illustrated in Figure 28 below.

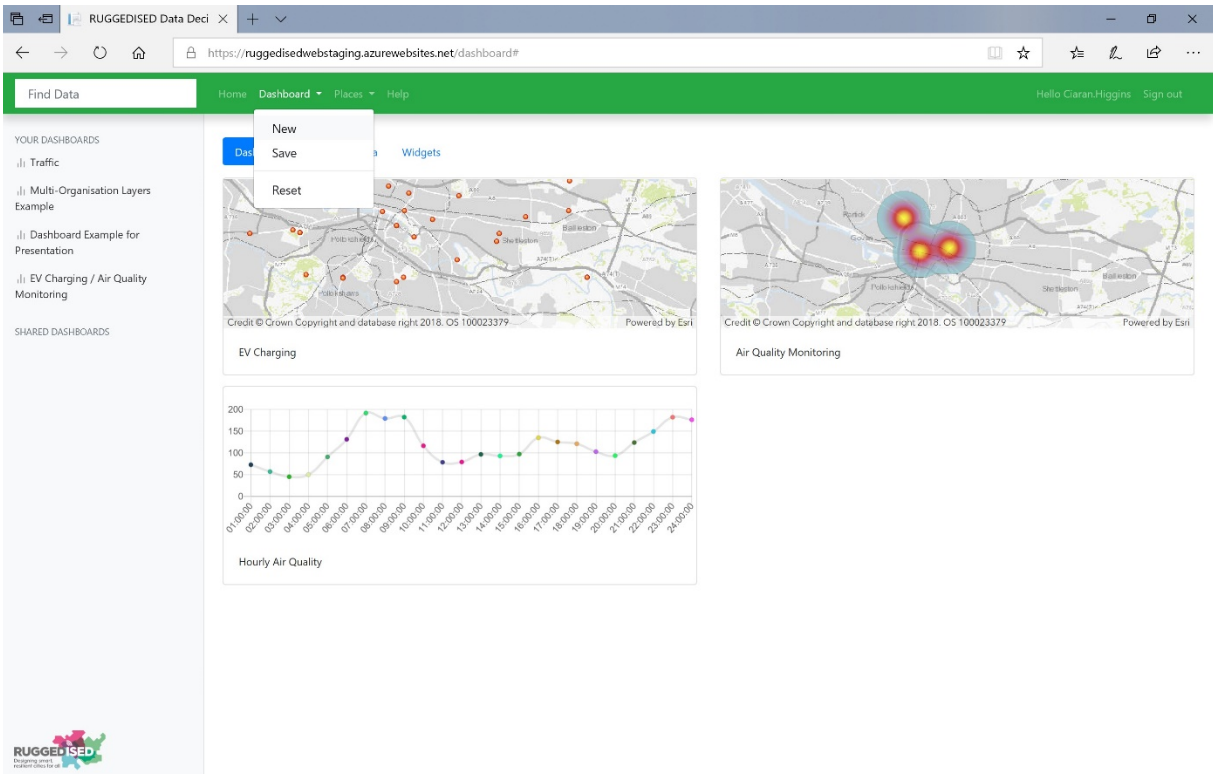


Figure 28. DBDP Creating a New Dashboard

The user will then be prompted with the following pop-up message.

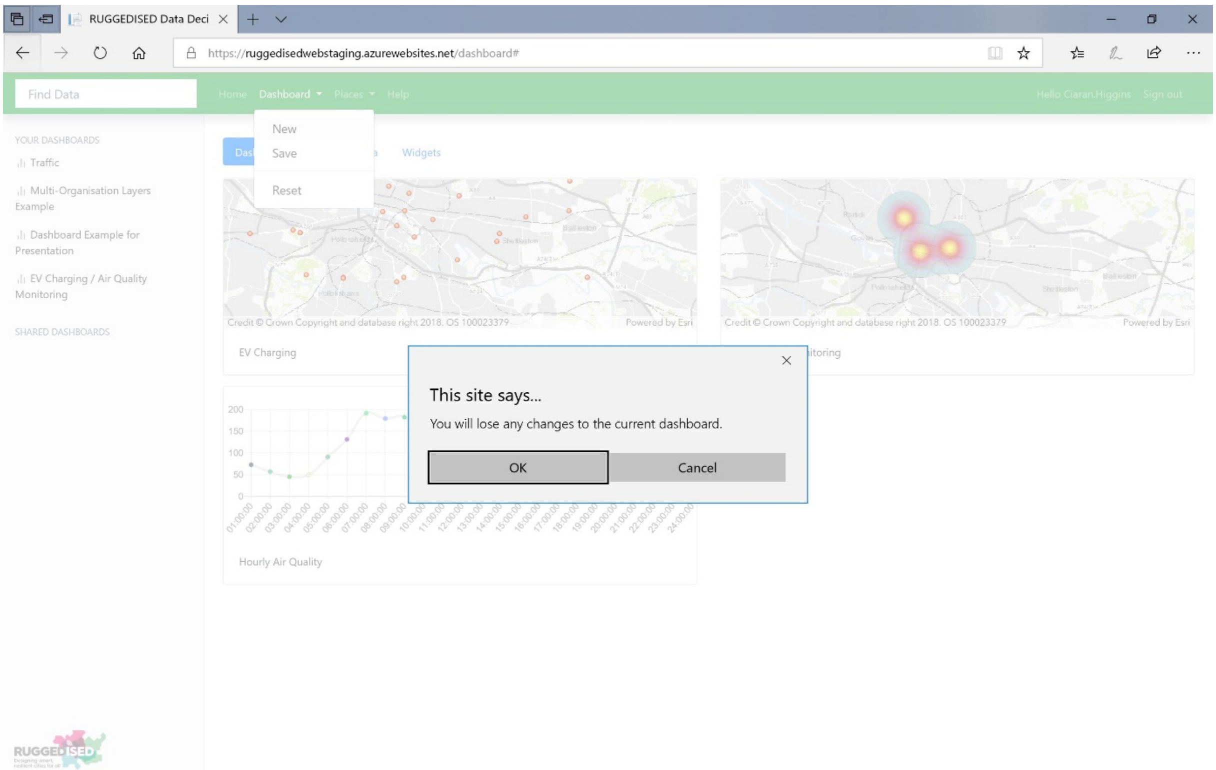


Figure 29. DBDP New Dashboard Pop-Up Message

Assuming all changes made to the existing dashboard have been saved, the user can click 'OK' and a new dashboard will be created. If the changes have not been saved, the user can simply click 'Cancel', which will bring them back to the original dashboard to allow it to be saved.

When the new dashboard has been selected, the user will be presented with a blank screen. They can then add widgets as described earlier in the document.

2.2.9 Sharing Dashboards

The user also has the option to share the dashboard with other users. For others to view the dashboard, the users simply needs to click on Share button on the top ribbon and the option 'Share Dashboard' will appear. This is illustrated in Figure 30 below.

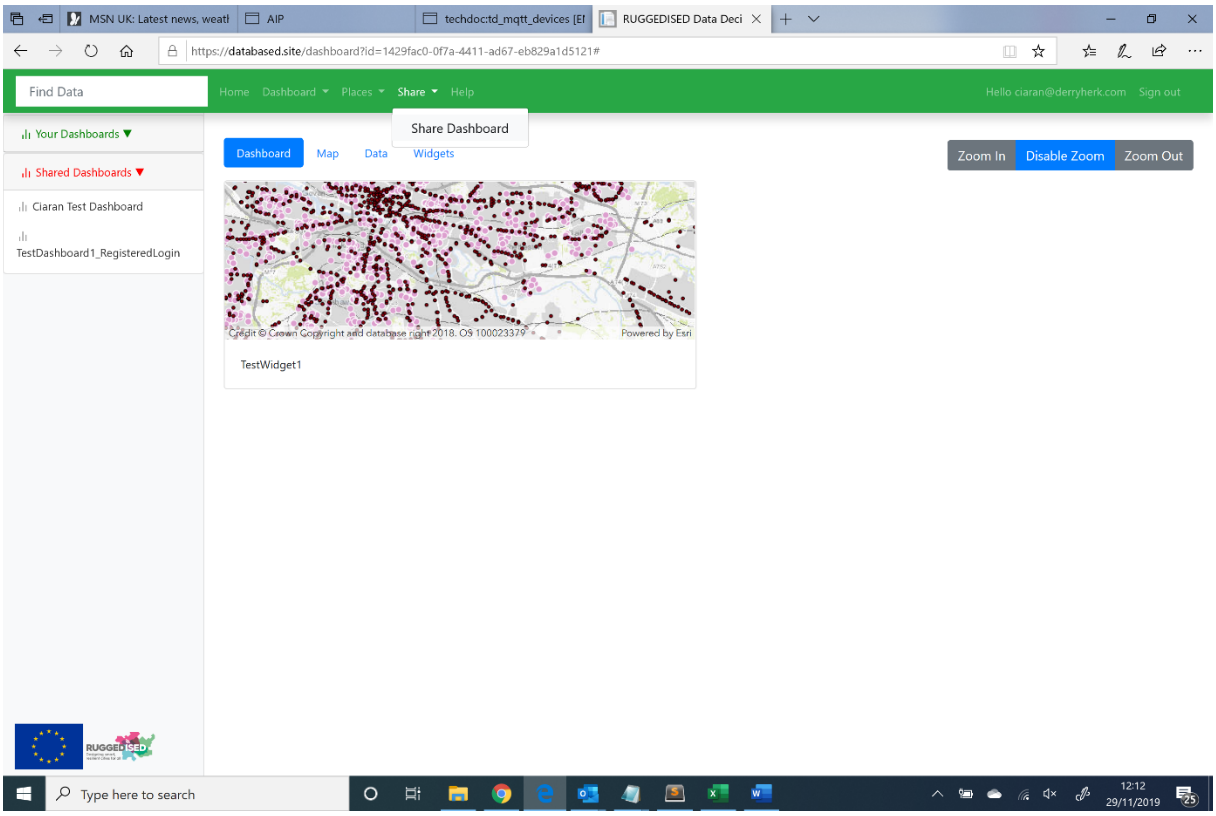


Figure 30. DBDP Share Dashboard Option

When selected the user is presented with a pop-up that has the URL for the dashboard that can be shared with other users. To retrieve the URL, simply click on 'Copy Url', shown in Figure 31 below. This will be copied to users' clipboards so that they can paste it into an e-mail or document for wider circulation.

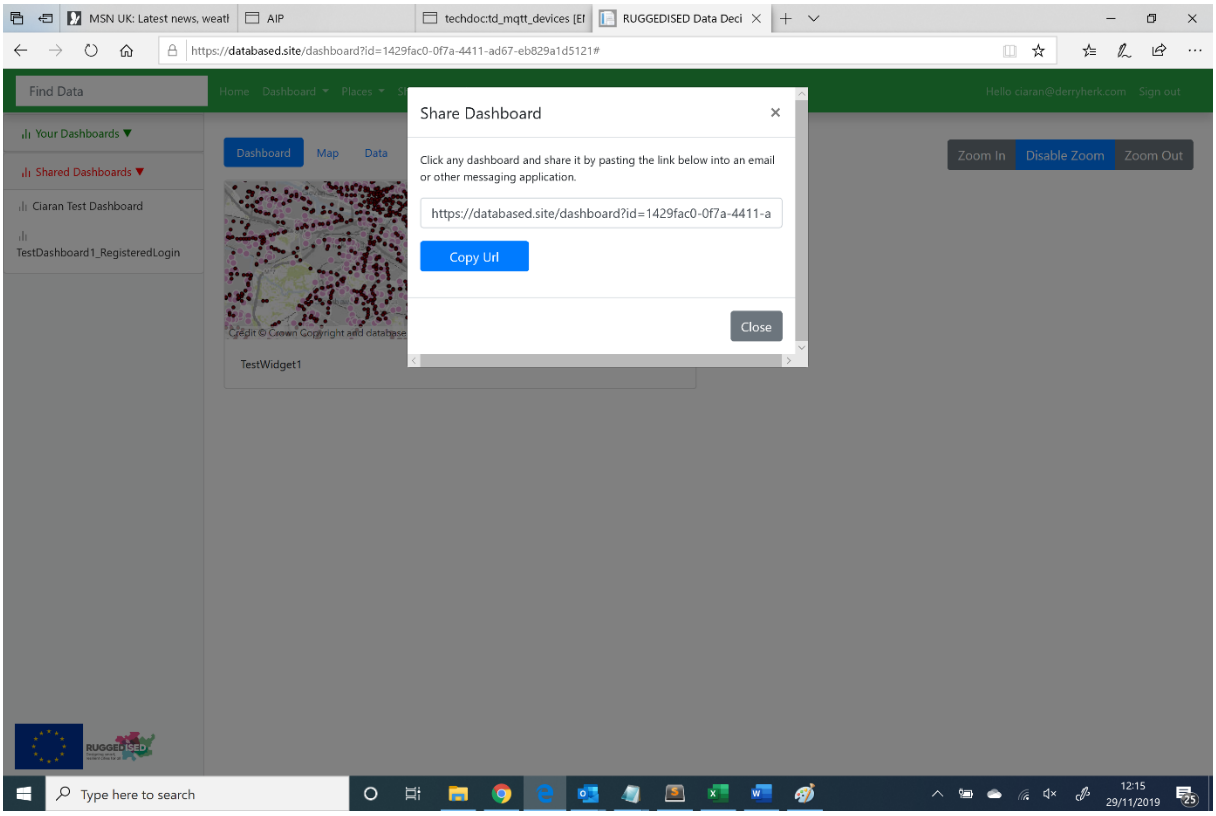


Figure 31. DBDP Shared Dashboards URL

2.3 Use Cases

As mentioned earlier in the document a couple of Use Cases have been developed to illustrate the tool working and to demonstrate that it meets the requirements. These Use Cases are based on the descriptions found in Section **Fout! Verwijzingsbron niet gevonden.** & **Fout! Verwijzingsbron niet gevonden.** earlier in the document. These Use Cases have also been referenced in the video found in Section 1.4.

2.3.1 Use Case 1: EV data analysis

In order to demonstrate this Use Case, the following datasets have been used:

1. Feed of EV usage for a select number of EVs within Duke Street Car Park [future data mocked up for purposes of demonstration]
2. Renewables opportunity layer, which ranks a number of Vacant & Derelict Land sites across the city according to the ease with which renewables could be deployed. This takes into account both technical constraints as well as policy constraints that could promote/prevent renewables deployment.
3. Energy demand layer, taken from UK Government energy statistics, which shows areas of high consumption across the city

Figure 32 below shows the DBDP with the 3 layers loaded. These layers were correct at the time of writing (October 2019).

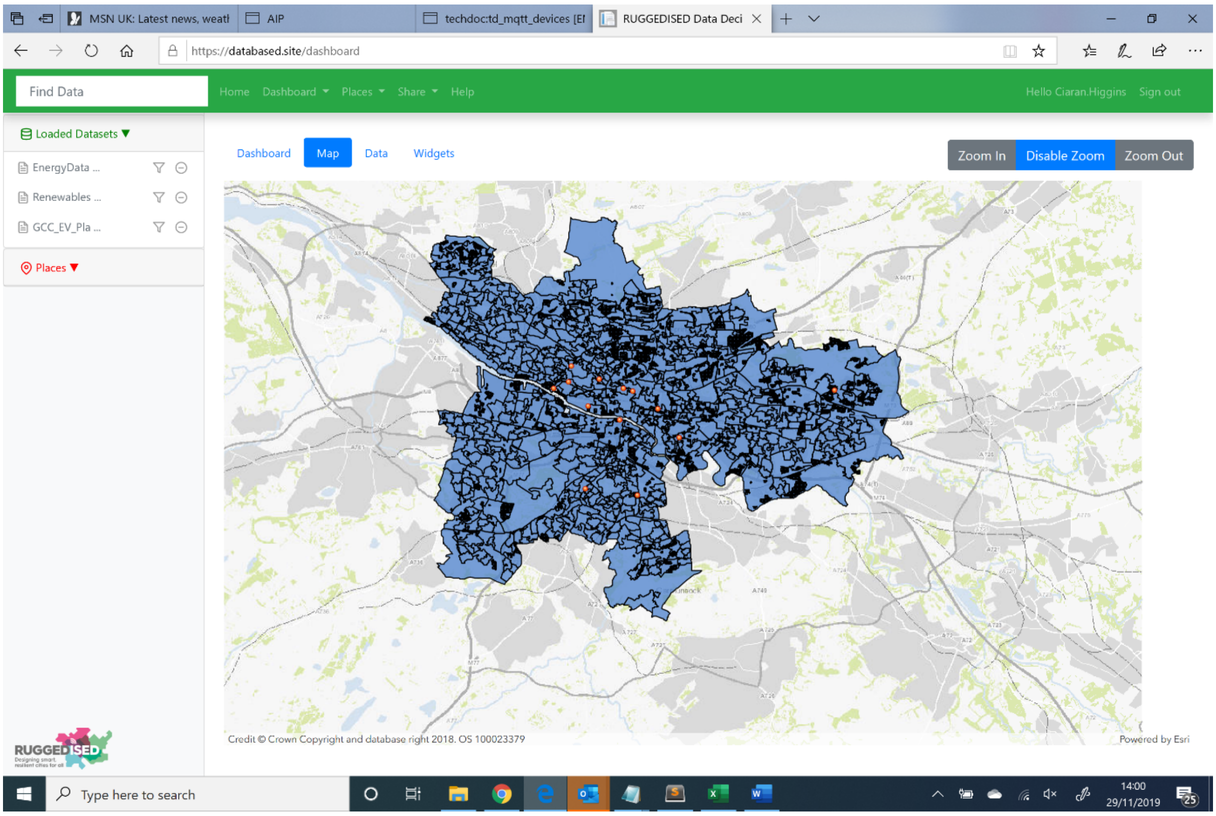


Figure 32. DBDP Use Case 1 Layers Loaded

If monitoring these layers via a dashboard, it is likely that two widgets would be added: a map that shows the location of each charger, symbolised in such a manner to show average utilisation of the charger; and a chart that shows the detailed utilisation figures.

Given the static nature of the energy demand and renewables opportunity layers, there is no need to add them to a dashboard as they will not change for several years (10 in the case of the Energy demand layer). How they would be used on the overall analysis to satisfy the Use Case is described in section 2.3.1.2 below.

2.3.1.1 Temporal Comparisons: EV usage historically and currently

This Use Case seeks to compare current and historical utilisation levels. The best way to achieve this in the DBDP is to duplicate the map and charts widgets and filter them so that only data from the historical period in question is displayed.

It is possible within ArcMap and AGOL to use the 'time slider' to show data changing over time, however the input data has to be manipulated to get it into the correct format for this type of visualisation. Therefore, a much simpler solution is to create a number of charts that relate to different points in time.

In this example, the EV usage data has a 'month' column, which can be used to extract data from a particular month. Therefore, 2 SQL filters are required:

```
"month" LIKE 'Jan%2019' → Historical data (winter)

"month" LIKE 'Jul%2019' → Historical data (summer)

"month" LIKE 'Dec%2019' → Current data
```

The resulting map/chart widgets are shown in Figure 33 below.

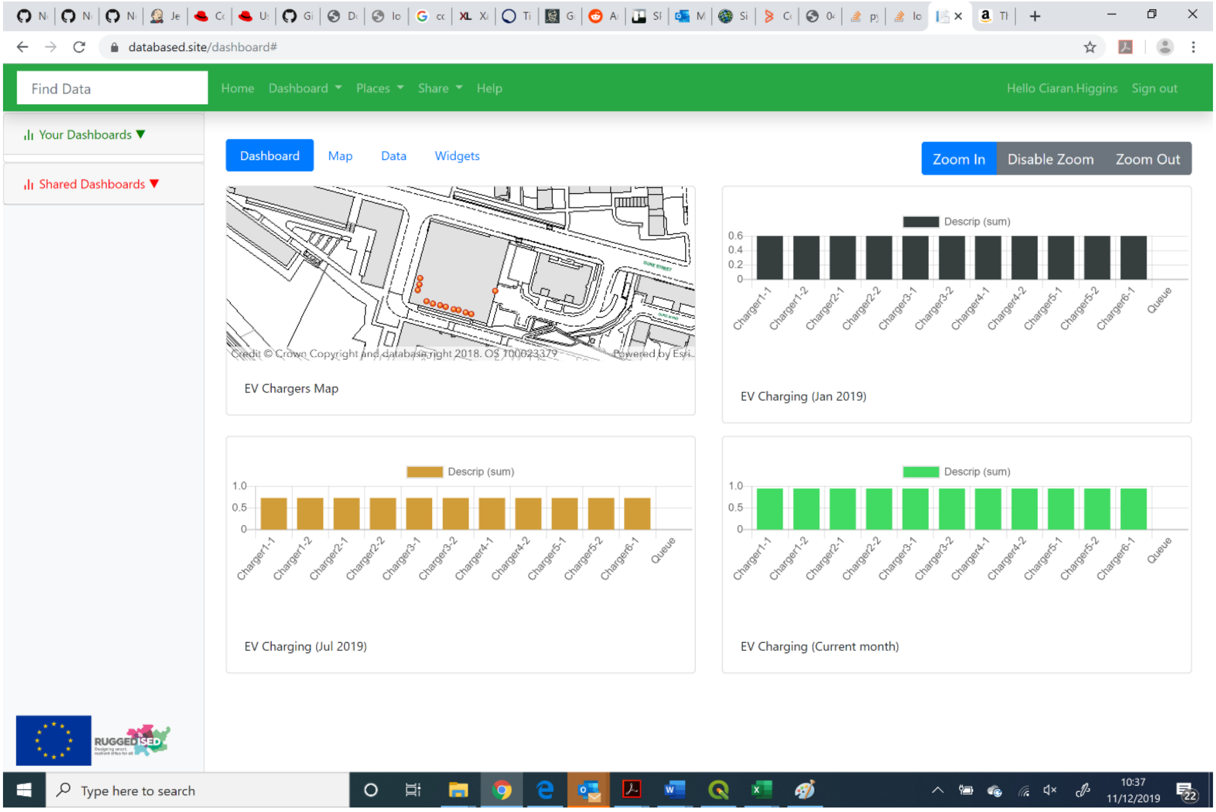


Figure 33. DBDP Comparing historical and current EV charging utilisations

Please note that it is possible to apply 2 different filters to the same layer, but only if that layer is loaded into another widget. This is entirely consistent with the behaviour of the majority of GIS toolsets.

As can be seen from the 2019 EV charging levels, there are a number of chargers that are approaching 100 percent utilisation in December (1.0 is equivalent to 100%) and, therefore, more need to be added. Where to locate them will now be analysed.

2.3.1.2 Comparing EV Charger Data with Energy Layers

This Use Case states that new chargers should be sited near areas in the city where there is also the opportunity to deploy renewable energy sources and existing high energy demand. Therefore, the renewables opportunity layer, energy demand layer and EV utilisation layer are overlaid onto the same map, illustrated in Figure 34 below.

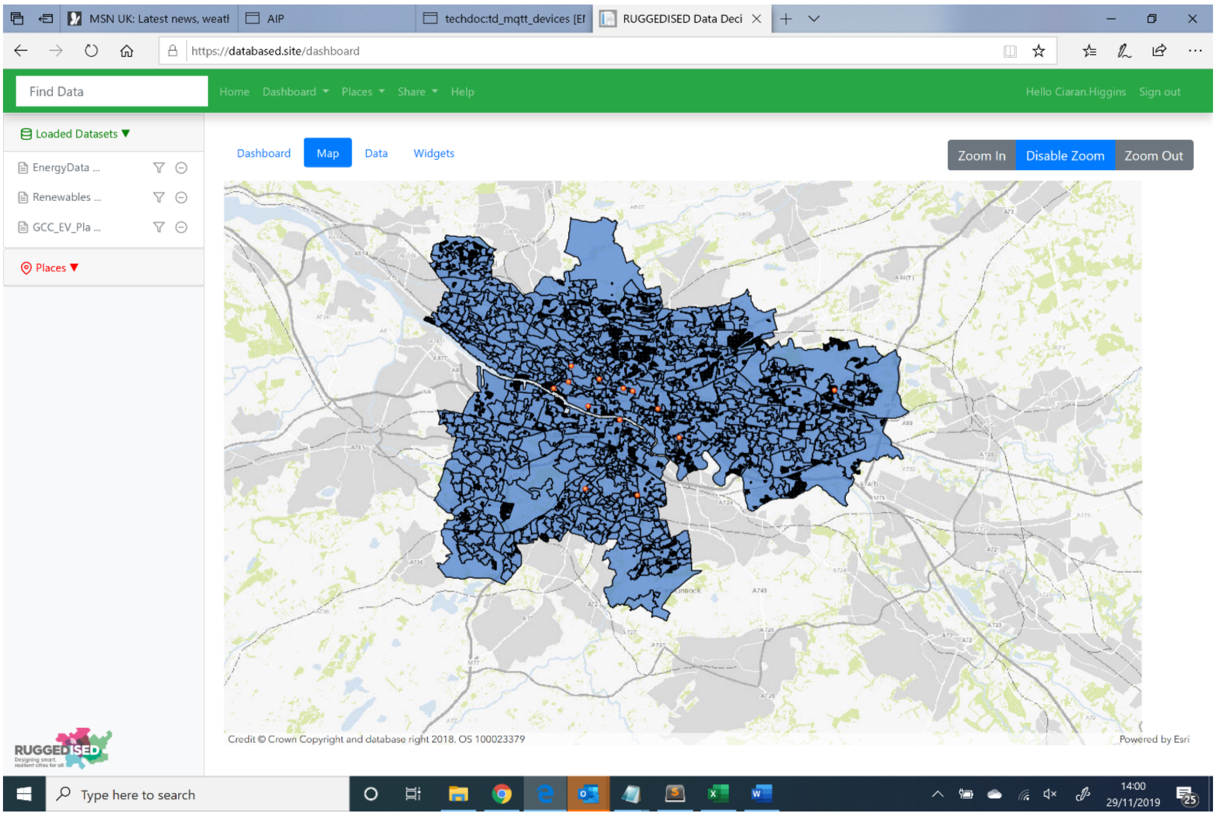


Figure 34. DBDP EV Charger Location Analysis Layers

The renewables deployment sites closest to both highly-utilised EV chargers and energy demand can be done in a number of ways. First of all, the user can simply look at the map and identify locations that match the criteria. This analysis can be aided by filtering each layer to display only the attributes that are relevant – i.e. filter the opportunity layer for sites that are 'Likely' and EV chargers that are > 90% utilised.

There are GIS analysis techniques that can be used, such as nearest-neighbour analysis that can be used to calculate the distance from one point layer to another. There are plans to add this analytical capability to the DBDP in the coming months. These will be available to the user via an 'Analysis' tab that will have a drop-down list of functions available. When selected, the user will be prompted to indicate the layers / fields that will be used in the function, as well as the output layer / data that will be presented back to the user via the existing tabs.

Figure 35 below shows the output of such analysis (imported for demonstration).

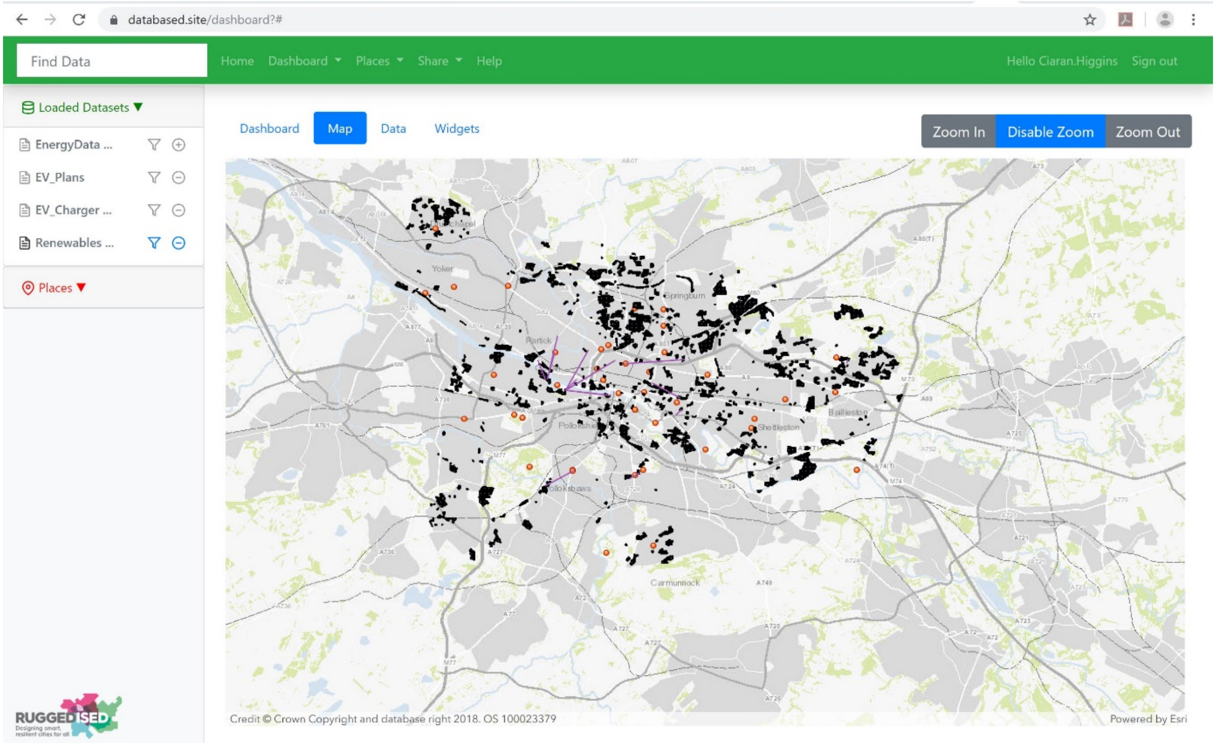


Figure 35. DBDP Nearest Neighbour Analysis [EV chargers to VDL land]

2.3.1.3 Adding traffic flow & car park data

The analysis could be further enhanced by adding layers such as traffic flow and car park data, all of which are readily available through the DBDP. Figure 36 below shows the same figure as above, but with traffic flow added to illustrate where the majority of traffic flows across the city.

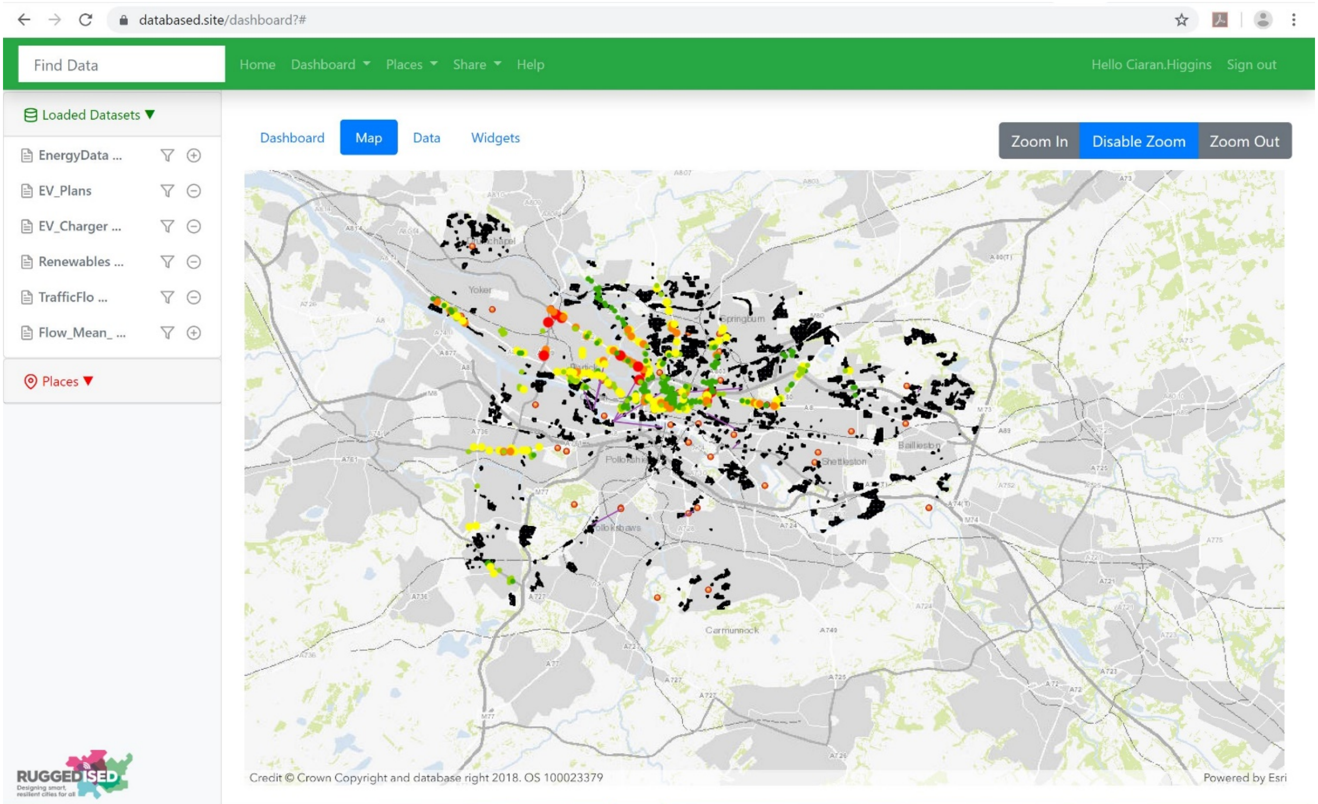


Figure 36. DBDP Addition of Traffic Flow

2.3.1.4 Use Case Conclusion

This section has demonstrated that the DBDP has the required functionality to consume & display the layers necessary to analyse EV charger utilisation across the city and to overlay these results onto layers that will help identify new locations for additional charger deployment.

2.3.2 Use Case 2: Smart Open Data Decision Platform

The second Use Case is based around the need to provide:

> *… a tool that will provide the analytical engine to allow citizens and businesses in the community to better access and analyse open data. Through this analytical assistance, citizens will be better placed to contribute to solutions both specific to their community and to the wider city. (see Task Description)*

As stated on numerous occasions in this report, GCC uses the ESRI suite to analyse GIS datasets, however this is rarely available to citizens and business due to license costs and the domain-specific knowledge required to use these toolsets.

Open source software is available in the form of QGIS (https://qgis.org/en/site/), however, like all other GIS products, there is domain-specific knowledge required to perform even the simplest of tasks. Furthermore, it is not currently possible to load web feature layers – the layers loaded into AGOL

The DBDP, however, as illustrated throughout this report, has an intuitive interface that can consume and render all industry-standard data types without the need for costly licenses. Imported data can be either direct API calls so that data appears in real-time all the way through to locally held files uploaded directly from the user's computer.

Users, which could easily be communities or businesses, can create logins and use the tool like anyone in GCC. Figure 37 below shows the login screen.

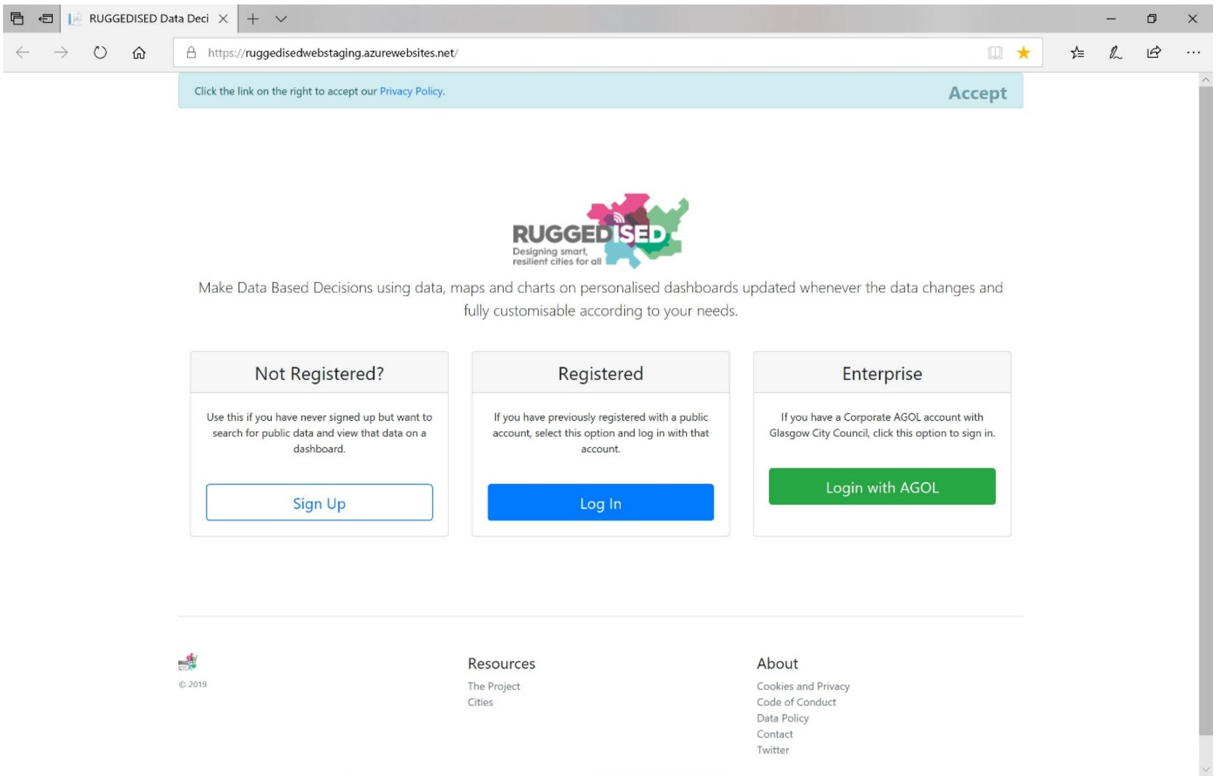


Figure 37. DBDP Login Screen

They can simply register with the DBDP and login as a ‘Registered User’, the process for which is described in Section 2.2.1 earlier in the report.

3 Assessment of Solution Effectiveness

If considering whether the solution developed meets the deliverable description for the DBDP, the exact wording from the Grant Agreement is found below:

A link to, and screenshot of, the fully formed data based decision ICT platform that integrates open data generated by the deliverables in WP4, as well as existing data and data generated by connected sensors deployed through a series of complimentary smart city initiatives, funded externally to the project. In addition, a case study illustrating the use of the decision platform will be included.

From this report and the examples provided, it is clear that the DBDP developed meets these criteria. Indeed, in many regards, they have been surpassed.

The loading of the sensor data will be done via an API, much like any other API illustrated throughout this report. As soon as the sensor data is available, it will be brought into the DBDP and dashboards showing the outputs from each created for wider dissemination.

3.1 User Functionality

From a User Functionality perspective, the DBDP is a web-based, intuitive interface that will allow non-GIS users to explore data and compare both geospatially and graphically via the charting widgets available.

3.2 Against Stated Deliverables

As stated above, the DBDP developed surpasses the original requirements and so the deliverable has been met.

4 Business Model Approach

The DBDP is a tool to improve decision making across the Council by making data more accessible allowing more informed decisions to be made. Wider access to the tool will facilitate the same in other key city stakeholders organisations, allowing the city to move forward in an efficient and informed manner.

From a technological perspective, the DBDP was designed to utilise existing toolsets as much as possible for two reasons:

- Familiarity to users already accustomed to the ESRI suite of products within GCC
- Utilisation of ESRI-supported Software Development Kit (SDK) to ensure compatibility with existing ESRI flows and to reduce support required

The latter point is the most important from a business model perspective as it reduces the resource required to support the tool in the future. Future costs will now be discussed.

4.1 Ongoing Costs

4.1.1 License costs

As a result of the architecture chosen, there are no ongoing license costs for the DBDP. Access to AGOL is subject to a license, but this is an overhead to GCC irrespective of the DBDP: the DBDP simply uses the login details to allow users to access various closed layers held within AGOL. All open layers are accessible with or without an AGOL login.

Users that only connect as a Registered User will incur no license costs whatsoever.

4.1.2 Maintenance & Support costs

Bug fixes and maintenance for the DBDP will be the responsibility of Council. The cost of the resource to provide this support is anticipated to be around £15,000 per annum, equivalent to around 30 days of a suitably qualified software developer. This will be funded on a rolling annual basis.

Beyond bug-fixing, there are no plans to provide support other than through help pages. This will be reviewed, however, on an ongoing basis.

4.1.3 Hosting costs

The DBDP will have to be hosted in order to be available to users via the web interface. There is a cost associated with this, as well as the cost of the URL, which is anticipated to be £306 per month or circa £3,700 per annum.

The breakdown of these costs is as follows:

- Staging environment = £70/month
- Live environment = £136/month
- Shared database = £90/month
- Sundry costs – storage, etc = £10/month

Please note that these costs are subject to change, depending on additional functionality that may be added and extra capacity to deal with an increased number of users.

4.2 Benefits to GCC

4.2.1 Upskilling – Increasing the Use of Data

The current suite of products used by the Council for GIS and data analysis have 2 distinct disadvantages:

1. Higher technical barrier to entry, as many of the tools – in particular the ArcMap GIS application – require detailed training; and
2. The cost of licensing these tools, particularly if they are not used regularly.

The DBDP, with its intuitive web-based interface, has a low technical barrier to entry, allowing users to load, manipulate and present data in a variety of ways.

4.2.2 Reduced License Costs

The DBDP is also not subject to license costs, therefore there is no waste in providing access to users, which may only use the tool a couple of times a year as it has no impact on the overall cost to GCC.

4.3 Future Upgrades

New functionality identified by users will be delivered on a case-by-case basis. This will typically be funded by projects, which identify use cases aligned to their funding and will be implemented by the Council's Data Team.

4.4 Expanding DBDP use

To maximise the impact of the DBDP, there is the potential to extend the use of the tool to different groups across the city. In order to fund future functionality, a small cost could be levied – significantly lower than would otherwise be incurred for Enterprise GIS / Data Analysis licenses – which will provide a number of logins to a particular organisation. At the time of writing, the exact model that will be used is yet to be agreed.

The use of such instruments, however, would have to be balanced against the desire to get other organisations using such a tool to allow better, data-driven decisions across the city.

4.5 Application of REPLICATE Template

The REPLICATE template has been suggested as a means to compare RUGGEDISED solutions against each other. The figure on the following page uses the template table provided by the Horizon 2020 SCC1 REPLICATE project, populated for the DBDP.

Key Partnerships	Key Activities / Key Infrastructure & Key Resources	Value Proposition	Buy in & Support / Deployment	Beneficiaries
Key Partnerships The key partnership is between the Glasgow City Council and key city stakeholders such as SP Energy Networks, Transport Scotland, GHA, etc.	**Key Activities** Creation of DBDP Identification of useful datasets in and out of GCC. **Key Infrastructure & Key Resources** DBDP tool GCC GIS & Data Teams IT hosting	**Value Proposition** Better policy through detailed analysis of datasets. Wider availability of data to key stakeholders, communities and businesses across city.	**Buy in & Support** GCC – Political, technical & financial **Deployment** Web-based application so it can be deployed to a wide range of users in GCC and to wider stakeholders.	**Beneficiaries** GCC will benefit through more efficient, data-driven policy making. Wider city will benefit through analysis of data to allow them to deliver their services more effectively.

Budget Costs Capital cost of tool covered. Ongoing maintenance & hosting costs. Future tool upgrades through ad-hoc funding applications based on need.	**Revenue Stream** Possible revenue streams through potential charge for use of tool in stakeholder organisations.
Environmental cost None.	**Environmental Benefits** Better policy within GCC that can derive environmental improvements, both locally and nationally.
Social Cost None.	**Social Benefits** Better policy within GCC that can derive societal improvements, both locally and nationally. Providing access to key city stakeholders could lead to better deliver of services to citizens.

A.1 Assessment of Existing Technology Options

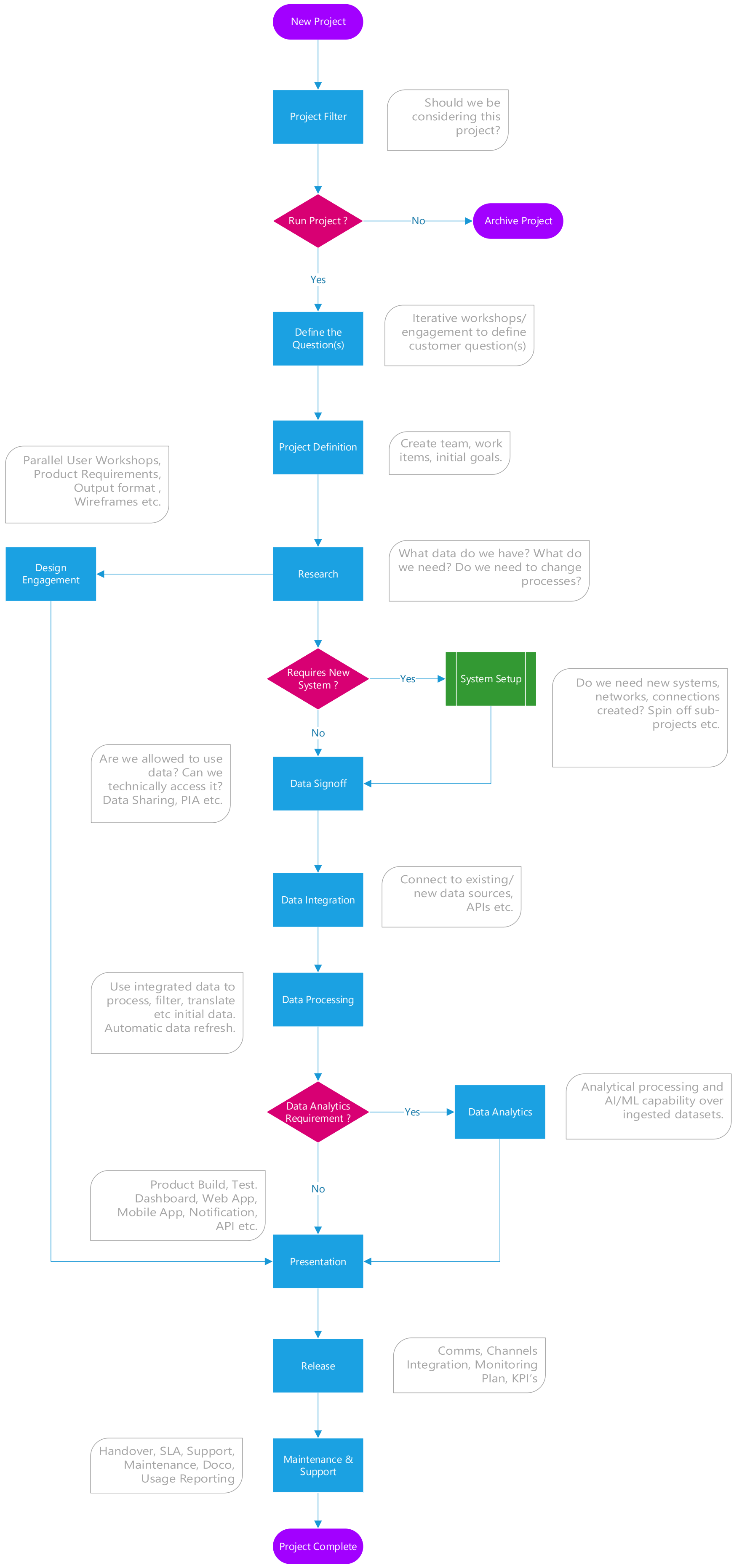
A.1.1 RUGGEDISED Data Decision Platform

The DBDP is a flexible data platform that will provide customisable dashboards to an array of users using data from various sources defined in the use cases below. It should be capable of being extended to support further use cases as well as be part of a long-term support model.

It is important to note that this technology is a combination of existing well establish technology and practices as well as newer innovative technologies that can provide new capability. Earlier research on this project also helped demonstrate the use of existing technologies to new innovative business requirements.

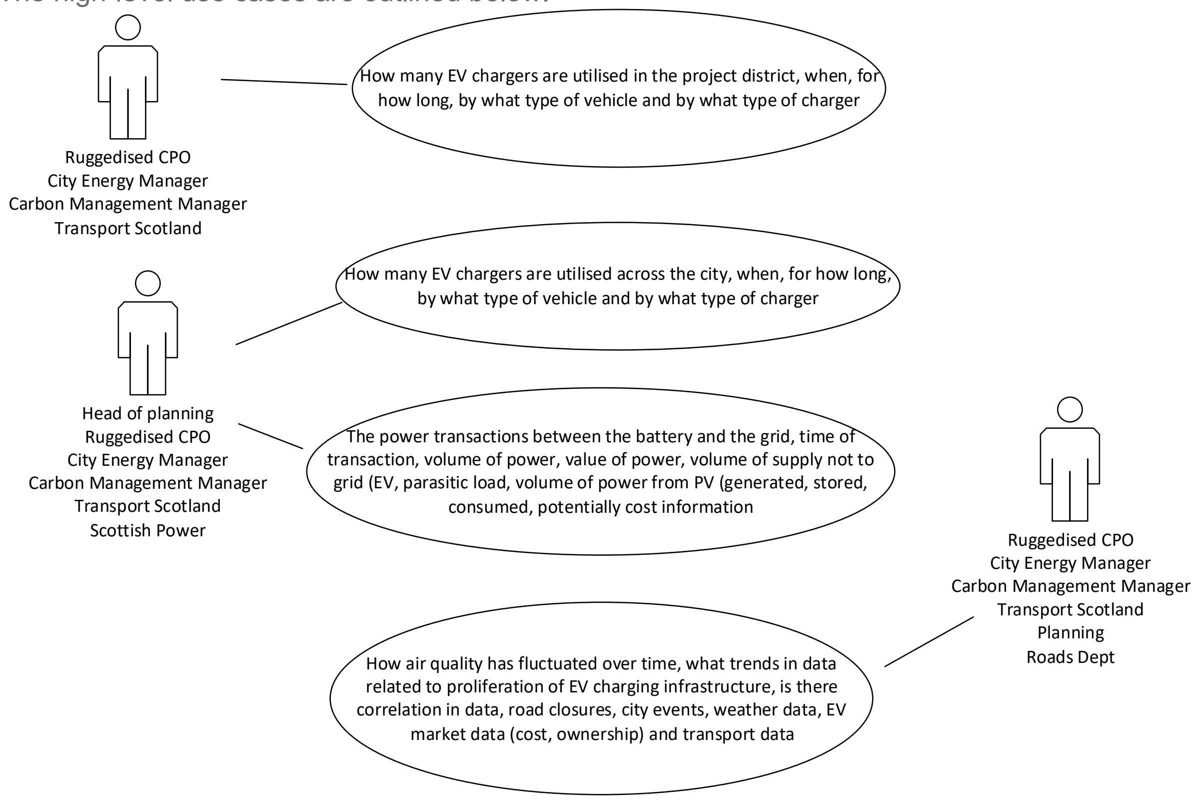
A.1.2 End to End Project Workflow

The following flow diagram shows the higher-level processes through which the initial Ruggedised project and further iterations go through. Please note that this process in itself is iterative and should change as the organisation as a whole defines the sub-processed outlined in each box.


New Project
Project Filter
Should we be considering this project?
Run Project ?
No
Archive Project
Yes
Define the Question(s)
Iterative workshops/ engagement to define customer question(s)
Project Definition
Create team, work items, initial goals.
Parallel User Workshops, Product Requirements, Output format , Wireframes etc.
Design Engagement
Research
What data do we have? What do we need? Do we need to change processes?
Requires New System ?
Yes
System Setup
Do we need new systems, networks, connections created? Spin off sub-projects etc.
No
Are we allowed to use data? Can we technically access it? Data Sharing, PIA etc.
Data Signoff
Data Integration
Connect to existing/ new data sources, APIs etc.
Use integrated data to process, filter, translate etc initial data. Automatic data refresh.
Data Processing
Data Analytics Requirement ?
Yes
Data Analytics
Analytical processing and AI/ML capability over ingested datasets.
No
Product Build, Test. Dashboard, Web App, Mobile App, Notification, API etc.
Presentation
Release
Comms, Channels Integration, Monitoring Plan, KPI's
Handover, SLA, Support, Maintenance, Doco, Usage Reporting
Maintenance & Support
Project Complete

A.1.3 Use Cases

The high-level use cases are outlined below.



Ref	As a …	I need to know …	So that I can decide …
UC1	Ruggedised CPO/ City Energy Manager/ Carbon Management Manager/ Transport Scotland	How many EV chargers are utilised in the project district, when, for how long, by what type of vehicle and by what type of charger	Where more chargers are required across the city, when to be deployed, at what cost, and what type of chargers by time of use and type of use.
UC2	Head of planning/ Ruggedised CPO/ City Energy Manager/ Carbon Management Manager/ Transport Scotland/ Scottish Power	How many EV chargers are utilised across the city, when, for how long, by what type of vehicle and by what type of charger	Where more chargers are required across the city, when to be deployed, at what cost, and what type of chargers by time of use and type of use.
UC3	Head of planning/ Ruggedised CPO/ City Energy Manager/ Carbon Management Manager/ Transport Scotland/ Scottish Power	The power transactions between the battery and the grid, time of transaction, volume of power, value of power, volume of supply not to grid (EV, parasitic load, volume of power from PV (generated, stored, consumed, potentially cost information	Where to target development of future micro grids to support the grid/fuel poverty
UC4	Ruggedised CPO/ City Energy Manager/ Carbon Management	How air quality has fluctuated over time, what trends in data	Report on the changes to the city, proposed

	Manager/ Transport Scotland/ planning/ roads dept	related to proliferation of EV charging infrastructure, is there correlation in data, road closures, city events, weather data, EV market data (cost, ownership) and transport data	infrastructure and successes

These can be broken down into more specific user cases (particularly around the measurable items).

Ref	As a …	I need to know …	So that I can decide …
UC1	**Ruggedised CPO/ City Energy Manager/ Carbon Management Manager/ Transport Scotland**	How many EV chargers are utilised in the project district	Where more chargers are required across the city, when to be deployed, at what cost, and what type of chargers by time of use and type of use
UC1	**Ruggedised CPO/ City Energy Manager/ Carbon Management Manager/ Transport Scotland**	When EV chargers are utilised in the project district	When to deploy more chargers across the city
UC1	**Ruggedised CPO/ City Energy Manager/ Carbon Management Manager/ Transport Scotland**	For how long EV chargers are utilised in the project district	At what cost, and what type of chargers by time of use and type of use
UC1	**Ruggedised CPO/ City Energy Manager/ Carbon Management Manager/ Transport Scotland**	What types of vehicles use EV chargers that are utilised in the project district	At what cost, and what type of chargers by time of use and type of use
UC1	**Ruggedised CPO/ City Energy Manager/ Carbon Management Manager/ Transport Scotland**	What type of EV chargers are utilised in the project district	At what cost, and what type of chargers by time of use and type of use
UC2	**Head of planning/ Ruggedised CPO/ City Energy Manager/ Carbon Management Manager/ Transport Scotland/ Scottish Power**	How many EV chargers are utilised in the City	Where more chargers are required across the city, when to be deployed, at what cost, and what type of chargers by time of use and type of use.
UC2	**Head of planning/ Ruggedised CPO/ City Energy Manager/ Carbon Management Manager/ Transport Scotland/ Scottish Power**	When EV chargers are utilised in the City	
UC2	**Head of planning/ Ruggedised CPO/ City Energy Manager/ Carbon Management Manager/ Transport Scotland/ Scottish Power**	For how long EV chargers are utilised in the City	
UC2	**Head of planning/ Ruggedised CPO/ City Energy Manager/ Carbon Management Manager/**	What types of vehicles use EV chargers that are utilised in the City	

	Transport Scotland/ Scottish Power		
UC2	**Head of planning/ Ruggedised CPO/ City Energy Manager/ Carbon Management Manager/ Transport Scotland/ Scottish Power**	What type of EV chargers are utilised in the City	
UC3	**Head of planning/ Ruggedised CPO/ City Energy Manager/ Carbon Management Manager/ Transport Scotland/ Scottish Power**	The power transactions between the battery and the grid	Where to target development of future micro grids to support the grid/fuel poverty
UC3	**Head of planning/ Ruggedised CPO/ City Energy Manager/ Carbon Management Manager/ Transport Scotland/ Scottish Power**	The time of transaction between the battery and the grid	Where to target development of future micro grids to support the grid/fuel poverty
UC3	**Head of planning/ Ruggedised CPO/ City Energy Manager/ Carbon Management Manager/ Transport Scotland/ Scottish Power**	The volume of power between the battery and the grid	Where to target development of future micro grids to support the grid/fuel poverty
UC3	**Head of planning/ Ruggedised CPO/ City Energy Manager/ Carbon Management Manager/ Transport Scotland/ Scottish Power**	The value of power between the battery and the grid	Where to target development of future micro grids to support the grid/fuel poverty
UC3	**Head of planning/ Ruggedised CPO/ City Energy Manager/ Carbon Management Manager/ Transport Scotland/ Scottish Power**	The volume of supply not to grid (EV, parasitic load)	Where to target development of future micro grids to support the grid/fuel poverty
UC3	**Head of planning/ Ruggedised CPO/ City Energy Manager/ Carbon Management Manager/ Transport Scotland/ Scottish Power**	The volume of power from PV (generated, stored, consumed, potentially cost information)	Where to target development of future micro grids to support the grid/fuel poverty
UC4	**Ruggedised CPO/ City Energy Manager/ Carbon Management Manager/ Transport Scotland/ planning/ roads dept**	How air quality has fluctuated over time	Report on the changes to the city, proposed infrastructure and successes
UC4	**Ruggedised CPO/ City Energy Manager/ Carbon Management Manager/ Transport Scotland/ planning/ roads dept**	What trends in air quality data related to proliferation of EV charging infrastructure	Report on the changes to the city, proposed infrastructure and successes
UC4	**Ruggedised CPO/ City Energy Manager/ Carbon Management Manager/ Transport Scotland/ planning/ roads dept**	Is there a correlation in air quality data related to proliferation of EV charging infrastructure	Report on the changes to the city, proposed infrastructure and successes
UC4	**Ruggedised CPO/ City Energy Manager/ Carbon Management Manager/ Transport Scotland/ planning/ roads dept**	Are there other correlations in data with road closures, city events, weather data, EV market data (cost,	Report on the changes to the city, proposed infrastructure and successes

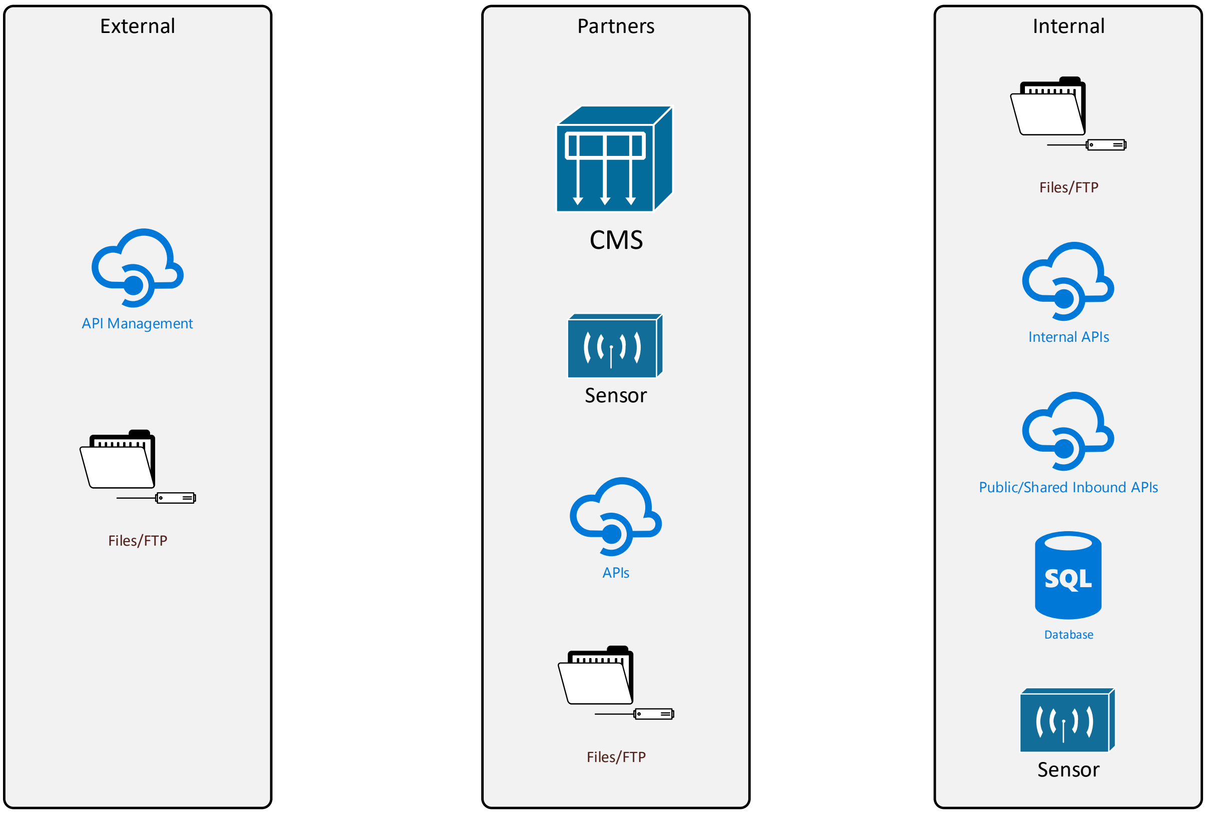
		ownership) and transport data	

A.1.4Data Sources

The specific data sources and datasets are defined in the core integrations section below – during the project an iterative approach has been taken as dataset and requirements are identified in an agile manner. However, there are general several approaches that we can apply in general to connecting with candidate data sources. There general approach will provide an overview of this with specific details being provided as these are understood.

A.1.4.1 General Solution Overview

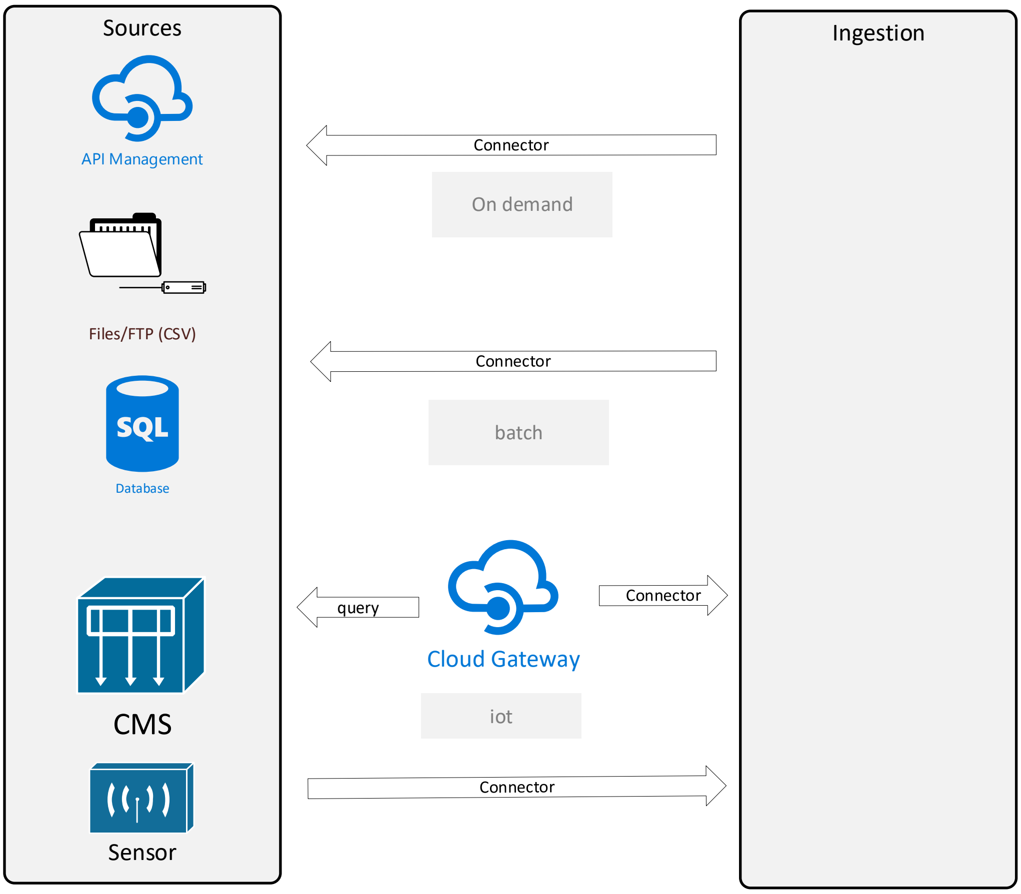
At a high level, the data sources can be generally grouped as follows.



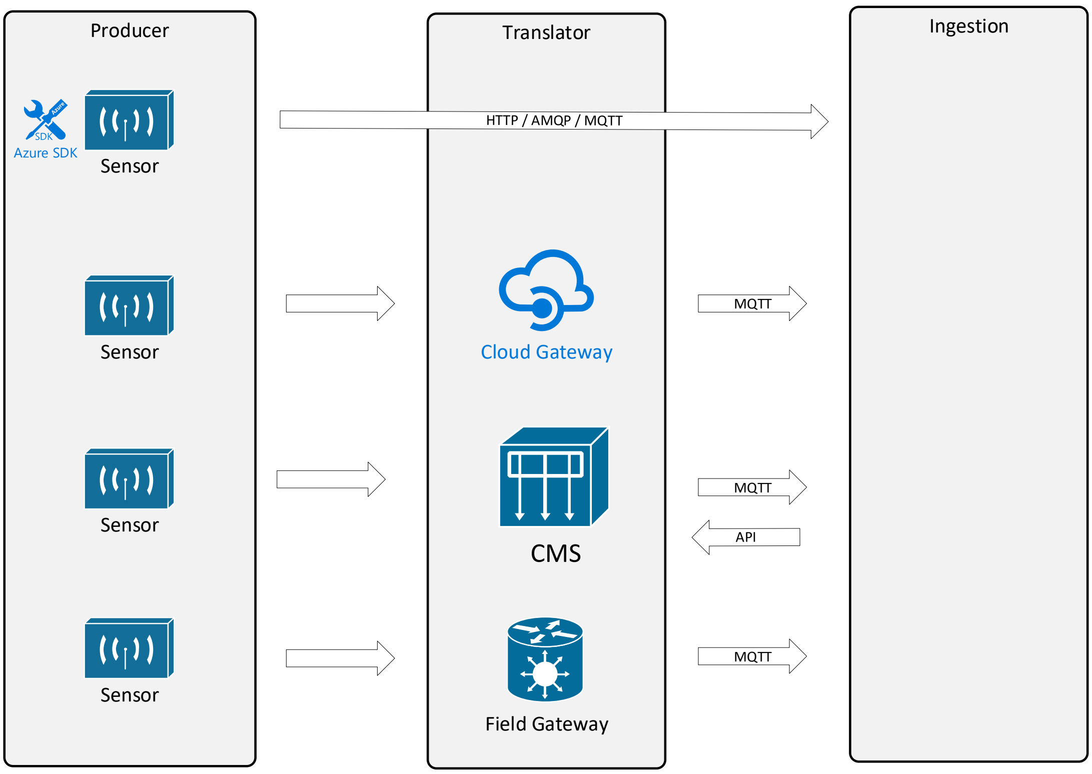
The data can be ingested in one of three ways.

"On Demand" sources typically APIs or CSV (smaller packets)	"Batch" data sources change less often; can be big data and/or varied data	"IoT" or Real Time is small amounts of rapidly changing data. - Can connect a sensor directly - May require a gateway (translation software) to connect an existing CMS to the integration platform

The general approach can be represented visually below.



Integrating the IoT data sources has a few options depending on the source. These are generally defined below but the specific approach will depend on the specific core integration.



A.1.5Data Integration & Processing

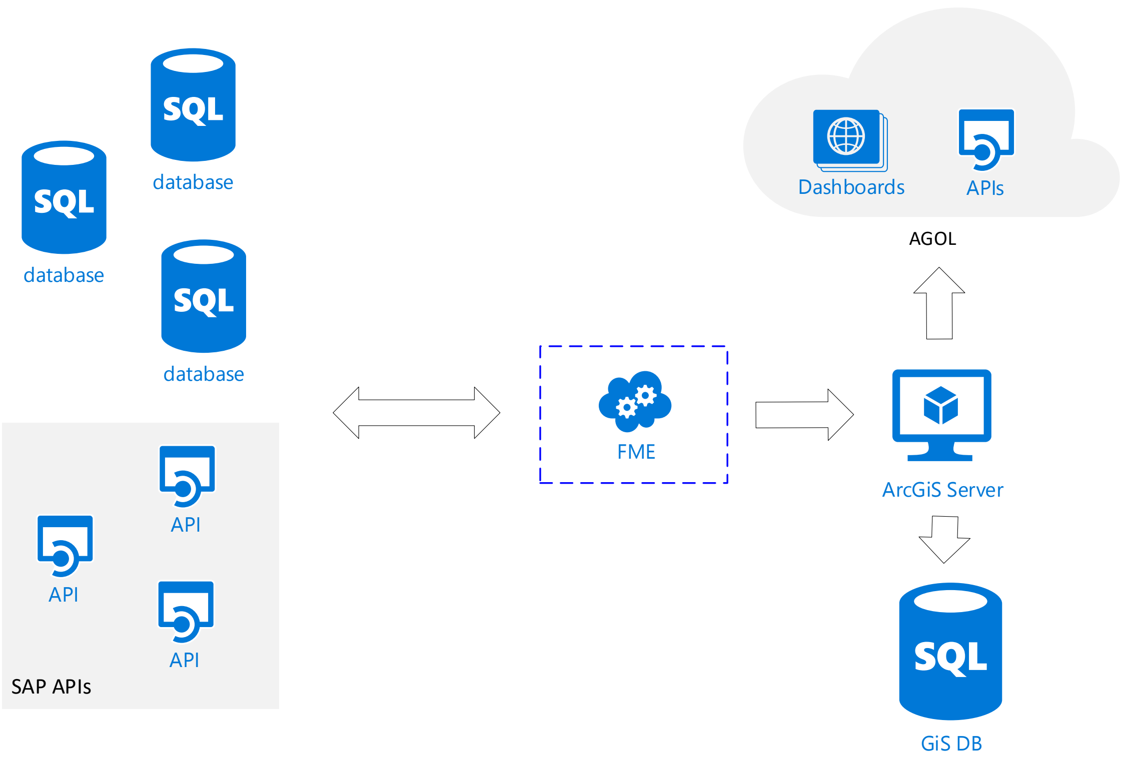
The specific data integrations and processing are defined in the core integrations section below – during the project an iterative approach has been taken as dataset and requirements are identified in an agile manner. However, there are general several approaches that we can apply to integrating candidate data sources. There general approach will provide an overview of this with specific details being provided as these are understood.

A.1.5.1 Corporate Data integration & Processing

GCC have existing data integration and processing capabilities in the form of ArcGIS and SAP Lumira. Initial work looked at using Data Factory to create data integration and processing pipelines but the changing technical contracts and other issues such as firewall issues, lack of a public endpoint to internal APIs and so on have made this less of an option when working with existing internal data. There current toolsets aren't as flexible but using toolsets such as ESRI ArcGIS, AGOL and FME, we can provide data integration and processing capability within the enterprise. Future developments should see the SAP products be part of that data integration and data processing pipeline.

It has been identified that the existing GIS infrastructure needs upgraded in order to address latency issues around the ESRI products.

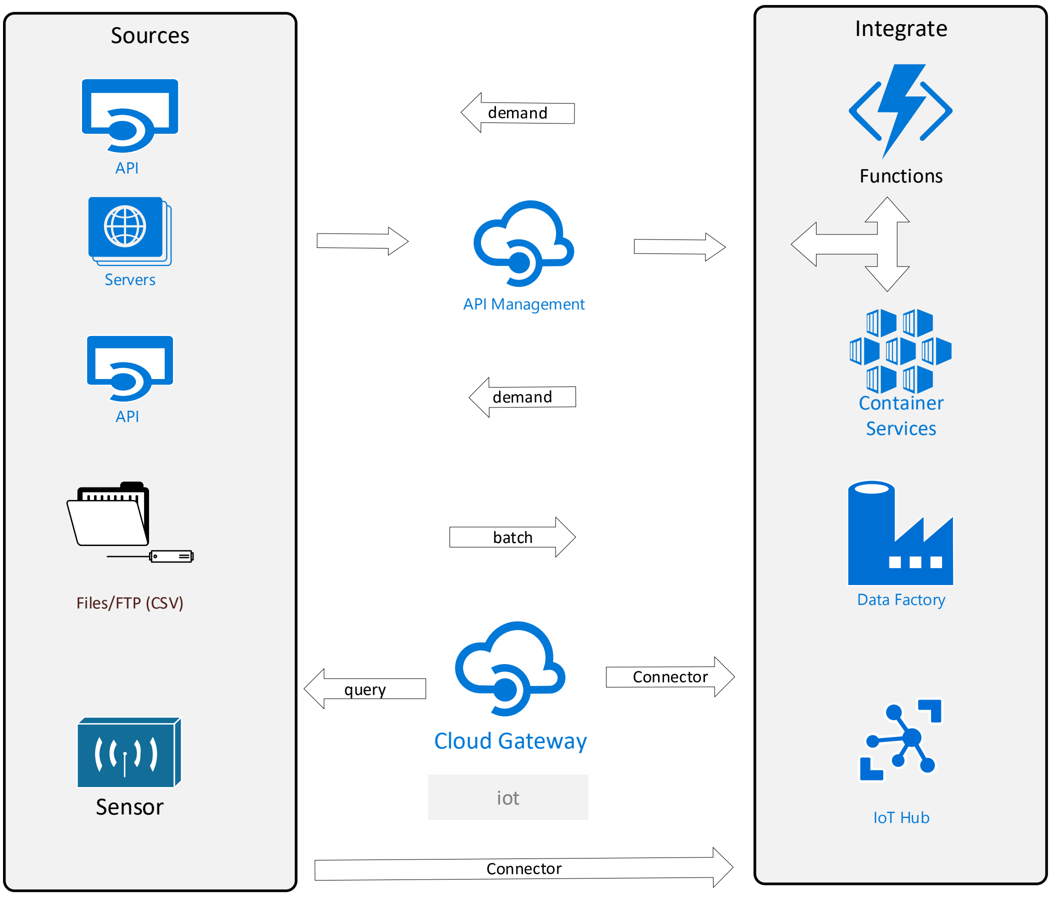
It is intended that the solution for the RUGGEDISED product use this infrastructure, including the work on data standards, data cataloguing and so on.
The high-level architecture of the GIS infrastructure is as follows. This is the currently supported Corporate infrastructure and more detail can be found from the GIS team and the infrastructure support team for this environment.



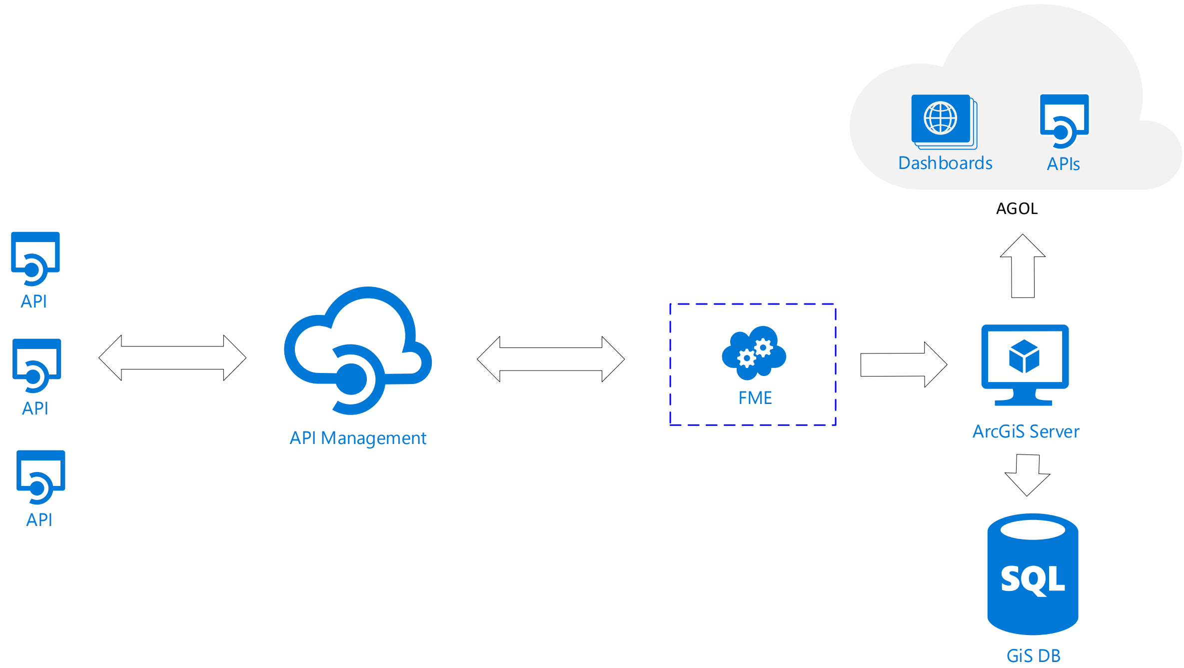
A.1.5.2 Azure Data Processing

In cases where there is external data integration required and in particular where there are IoT data integration requirements, advanced data processing requirement or extended flexibility, Microsoft Azure provides a range of technologies that can be used to complement the Corporate toolset.
At the time of development of the project, the Glasgow City Council IT Contract was in flux so there may be areas that could be migrated to a Corporate pipeline over time.
At a high level, the data integration can be generally represented as follows.

• Functions run at a schedule (or trigger) to make requests to the data sources • Container Services allow scheduled Docker instances to make requests • In-Bound data comes via a secure API • Data Factory integrates batch data sources on an automated schedule • Provide capability to process and clean the data • IoT Hub integrates IoT data either directly – or via a Cloud Gateway to act as an adapter.	• Azure Functions allow highly scalable on demand data processing in a number of languages – C#, Python, Java • Container Instances allow low cost, on demand [Docker] services in any language • Container Instances also allow any framework or additional software to be installed for your application • Both are on demand meaning you only pay for what you consume – this dramatically reduces cost.



Each integration that runs on Azure and needs integrated with the ArcGIS platform will provide an API and data format suitable for integration as follows.



A.1.6Data Presentation

Data will be presented using the existing ArcGIS Online software supported by the Council. Initial research looked at alternative approaches such as custom dashboard and SAP Lumira. The former would provide a custom experience for the platform but would incur issues in support and maintenance. The Lumira option was under upgrade and the flexibility did not allow us to add datasets and test the dashboard an in an iterative manner. As we understood more about the ESRI option it became evident this ticked most boxes.

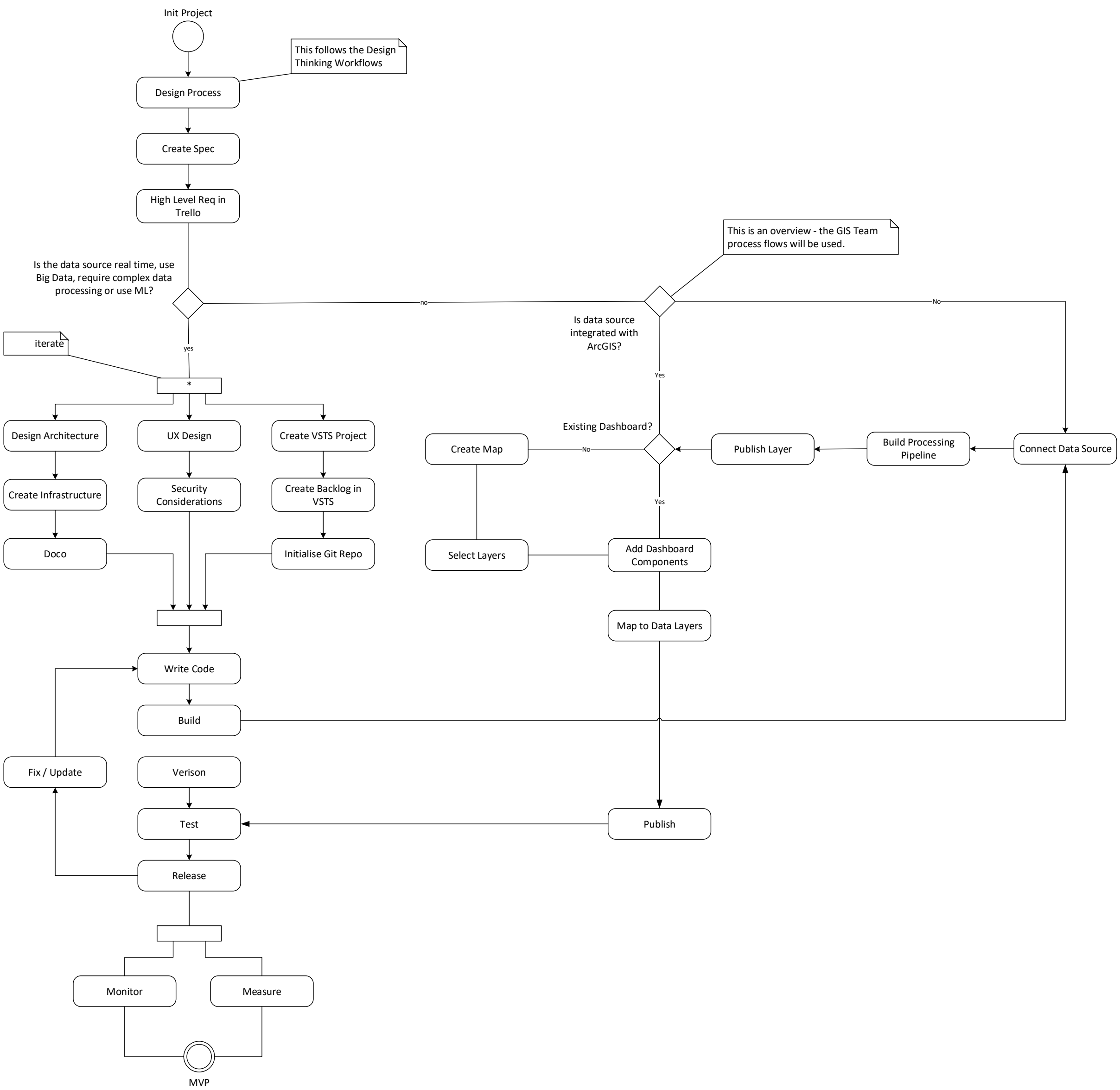
A.1.6.1 Corporate Data Dashboards

The creation or update process for a new dashboard will follow existing corporate processes as outlined in the Technical Integration Flow section below.

- Power BI Visualisations via the APIs
- Lumira consumption via api

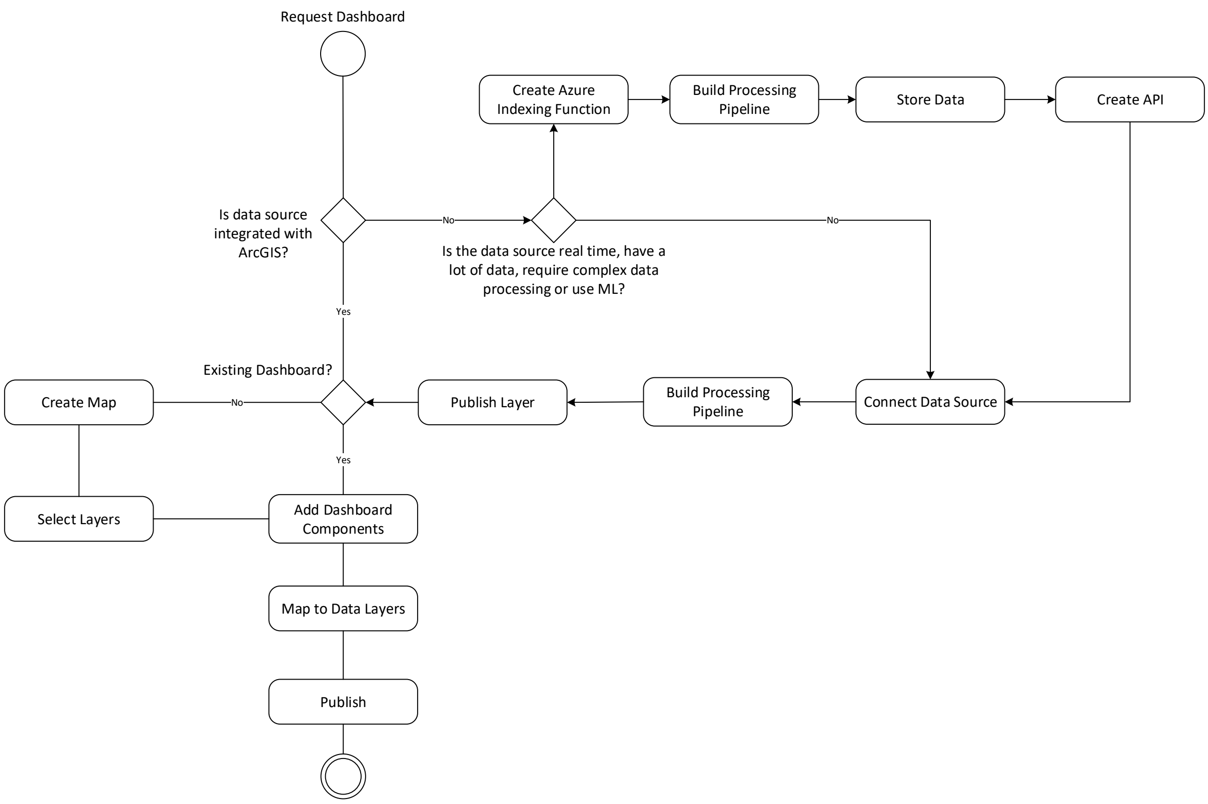
A.1.7Integration Process

Datasets or interfaces that are to be integrated into RUGGEDISED will follow the flow identified in the previous section. If the result of that flow is that work is required to be done on Azure (typically more complex data processing or using a capability available in the cloud) then the process flow outlined below is used. Note that at this stage we are identifying candidate integrations to get to an MVP stage and so the flow will not be as rigorous as a process that may take this to Business as Usual. In fact, the output of this process may be that is should *not* be made BAU.
Again, the specific configuration details will out set out in the Core Integrations section below.



A.1.8Technical Integration Flow

The above sections provide high level views of the various data integration processes and how these are presented to the end users. The following diagram summaries how these technical processes are connected together and the decision flow between them. The detail on the sub-processes are defined within the workflow of the GIS Team.



A.1.9Core Integrations

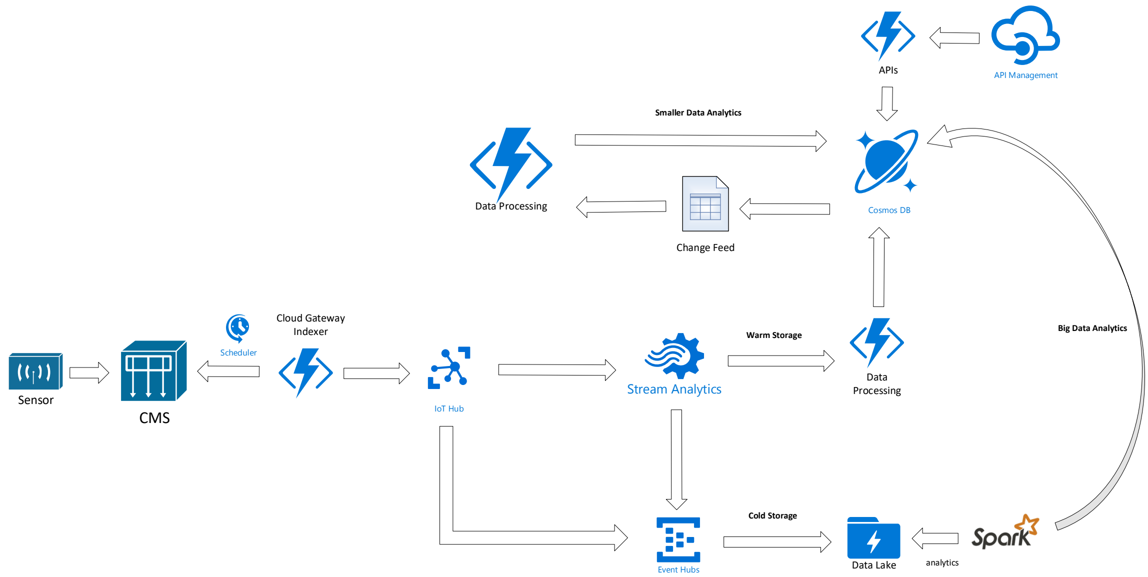
The purpose of the Data Decision Platform is to be able to iteratively scale to support emerging uses cases that wish to use Corporate datasets in a number of ways to answer City wide questions. There may be cases where new datasets are to be integrated in a way that is either not currently supported (e.g. Real time IoT integration), is not well understood and so an agile proof of concept integration is preferred or there is a preference for extended tooling capabilities not yet available or understood corporately (e.g. Sentiment analysis capability or Topic Analysis).
This section will look at the Core integrations and how these will be integrated as an application of the general technical approach outlined in the above sections.

A.1.9.1 iTron CMS

The iTron CMS is a hosted CMS that integrates the IoT devices as part of Glasgow's Intelligent Streetlight Network. An API is provided that allows us to integrate data from the devices.

A.1.9.1.1Technical Architecture

The architecture for this integration is as follows.



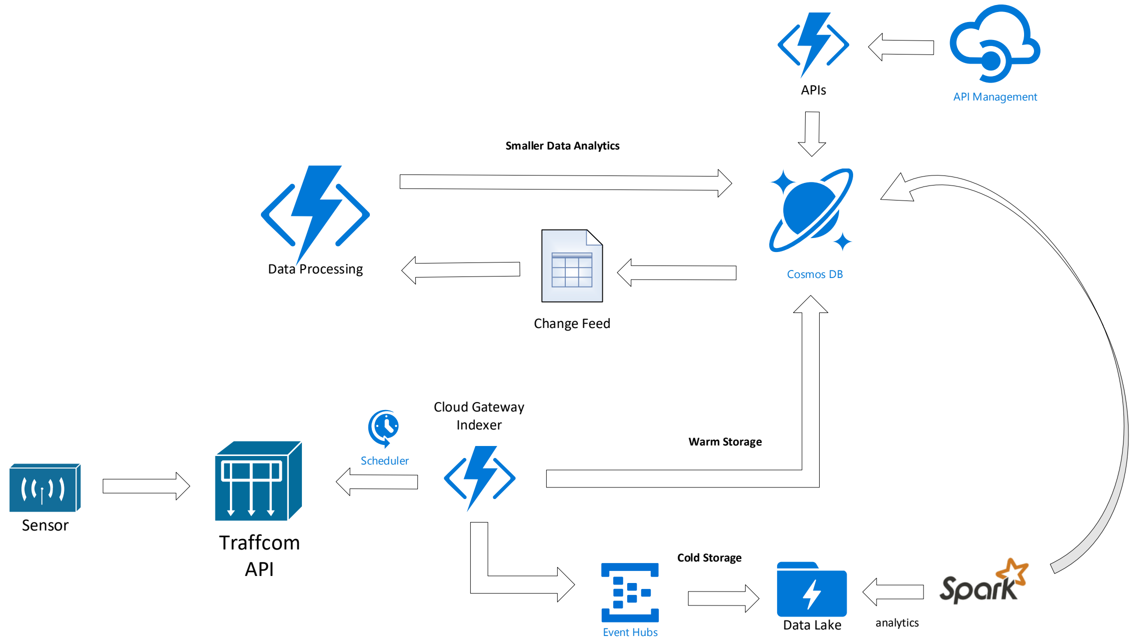
Order	Component	Function
1	Sensor	Sensor data is transmitted back to the CMS over a secure network.
2	CMS	CMS stores the sensor data and is hosted externally. The CMS provides APIs that allow us to query it to get the sensor measurements.
3	Gateway Indexer	A scalable scheduled Azure function using custom code written by us that regularly queries the CMS API, retrieves the measurements in JSON format and puts each record onto the IoT Hub.
4	IoT Hub	A massively scalable IoT messaging platform that allows us to route inbound messages at scale to a number of endpoints.
5a	Stream Analytics	Provides capability to do in-memory streaming analytics and filtering of records added to the IoT Hub. Used primarily where the calculations can be done in real time and in memory and so typically work over a short time window.
6a	* Data Processing	The output from in memory analytics can be passed to a scalable Azure function that can do further complex data processing prior to storage. * This is an optional component as you can route directly to CosmosDB from Streaming Analytics but it is common that you want additional processing prior to this.
7	CosmosDB	A massively scalable multi-model data store that persists calculated IoT measurement data.
8	Change Feed	The Change Feed is a component of CosmosDB that allows you to detect changed to a collection within the data store and perform additional processing.
9	* Data Processing	The changes detected in the Change Feed can be passed to a scalable Azure function that can do further complex data processing prior to storage. * This is an optional component as you can route directly to CosmosDB from Streaming Analytics but it is common that you want additional processing prior to this.
10	APIs	The APIs provide access logic to the data and perform the task and formatting inbound requests, performing the query and returning the data to the consumer.
11	API Management	API Management provides a managed API platform for securing access to our APIs. It provides security, rate limiting and so on.

5b	Event Hubs	IoT Hub can output to Event Hubs, a massively scalable messaging platform that can be joined with other cloud components to manage sensor measurements.
6b	Data Lake	Event Hubs are joined with Azure Data Lake to persist data as cold storage in a time sensitive hierarchical manner, allowing large, longer term queries and analytics to be made.
7b	Spark	Apache Spark provides a highly scalable data analytics framework which can - on demand or to schedule - ingest data from Azure Data Lake, run scripts written in R, Python and more and write the results to CosmosDB as in item 7 above.

A.1.9.2 Traffcom Traffic Data

Traffcom is the Council's traffic control centre which manages over 850 signal controlled junctions and crossings within the city. It uses intelligent transport systems to do this which can provide both real time passenger information (RTPI) and bus priority through an Urban Traffic Control (UTC) system. The Traffcom system provides us with near real time traffic flow and concentration data which we can integrate into RUGGEDISED as discussed below.

The architecture for this integration is as follows.

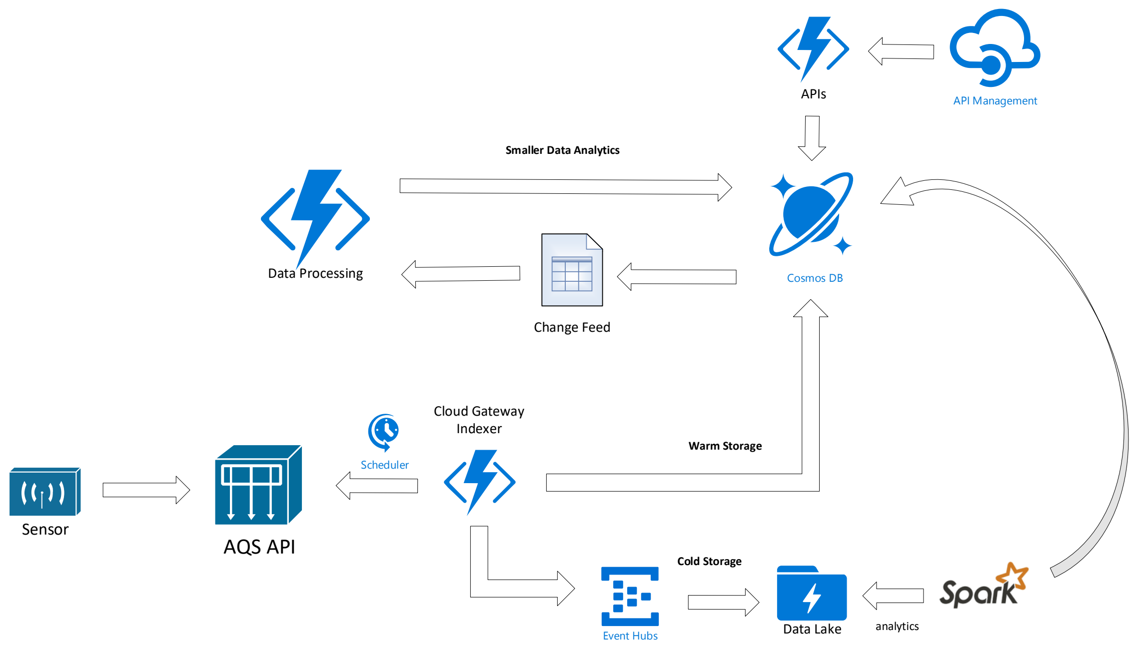


Order	Component	Function
1	Sensor	Sensor data is transmitted back to the Traffcom CMS over a secure network.
2	Traffcom API	Traffcom stores the sensor data and is hosted externally. The Traffcom CMS provides APIs that allow us to query it to get the sensor measurements.
3	Gateway Indexer	A scalable scheduled Azure function using custom code written by us that regularly queries the CMS API, retrieves the measurements in JSON format and puts each record onto the IoT Hub.
4	IoT Hub	A massively scalable IoT messaging platform that allows us to route inbound messages at scale to a number of endpoints.

5a	Stream Analytics	Provides capability to do in-memory streaming analytics and filtering of records added to the IoT Hub. Used primarily where the calculations can be done in real time and in memory and so typically work over a short time window.
6a	* Data Processing	The output from in memory analytics can be passed to a scalable Azure function that can do further complex data processing prior to storage. * This is an optional component as you can route directly to CosmosDB from Streaming Analytics but it is common that you want additional processing prior to this.
7	CosmosDB	A massively scalable multi-model data store that persists calculated IoT measurement data.
8	Change Feed	The Change Feed is a component of CosmosDB that allows you to detect changed to a collection within the data store and perform additional processing.
9	* Data Processing	The changes detected in the Change Feed can be passed to a scalable Azure function that can do further complex data processing prior to storage. * This is an optional component as you can route directly to CosmosDB from Streaming Analytics but it is common that you want additional processing prior to this.
10	APIs	The APIs provide access logic to the data and perform the task and formatting inbound requests, performing the query and returning the data to the consumer.
11	API Management	API Management provides a managed API platform for securing access to our APIs. It provides security, rate limiting and so on.
5b	Event Hubs	IoT Hub can output to Event Hubs, a massively scalable messaging platform that can be joined with other cloud components to manage sensor measurements.
6b	Data Lake	Event Hubs are joined with Azure Data Lake to persist data as cold storage in a time sensitive hierarchical manner, allowing large, longer term queries and analytics to be made.
7b	Spark	Apache Spark provides a highly scalable data analytics framework which can - on demand or to schedule - ingest data from Azure Data Lake, run scripts written in R, Python and more and write the results to CosmosDB as in item 7 above.

A.1.9.3 Air Quality Scotland

The architecture for this integration is as follows.



Order	Component	Function
1	Sensor	Sensor data is transmitted back to the Traffcom CMS over a secure network.
2	AQS API	AQS stores the sensor data and is hosted externally. The AQS CMS provides APIs that allow us to query it to get the sensor measurements.
3	Gateway Indexer	A scalable scheduled Azure function using custom code written by us that regularly queries the CMS API, retrieves the measurements in JSON format and puts each record onto the IoT Hub.
4	IoT Hub	A massively scalable IoT messaging platform that allows us to route inbound messages at scale to a number of endpoints.
5a	Stream Analytics	Provides capability to do in-memory streaming analytics and filtering of records added to the IoT Hub. Used primarily where the calculations can be done in real time and in memory and so typically work over a short time window.
6a	* Data Processing	The output from in memory analytics can be passed to a scalable Azure function that can do further complex data processing prior to storage. * This is an optional component as you can route directly to CosmosDB from Streaming Analytics but it is common that you want additional processing prior to this.
7	CosmosDB	A massively scalable multi-model data store that persists calculated IoT measurement data.
8	Change Feed	The Change Feed is a component of CosmosDB that allows you to detect changed to a collection within the data store and perform additional processing.
9	* Data Processing	The changes detected in the Change Feed can be passed to a scalable Azure function that can do further complex data processing prior to storage. * This is an optional component as you can route directly to CosmosDB from Streaming Analytics but it is common that you want additional processing prior to this.
10	APIs	The APIs provide access logic to the data and perform the task and formatting inbound requests, performing the query and returning the data to the consumer.
11	API Management	API Management provides a managed API platform for securing access to our APIs. It provides security, rate limiting and so on.

5b	Event Hubs	IoT Hub can output to Event Hubs, a massively scalable messaging platform that can be joined with other cloud components to manage sensor measurements.
6b	Data Lake	Event Hubs are joined with Azure Data Lake to persist data as cold storage in a time sensitive hierarchical manner, allowing large, longer term queries and analytics to be made.
7b	Spark	Apache Spark provides a highly scalable data analytics framework which can - on demand or to schedule - ingest data from Azure Data Lake, run scripts written in R, Python and more and write the results to CosmosDB as in item 7 above.