Requirements for CityGML visualisation tool

Purpose of this document

This document sets out the requirements for a CityGML visualisation tool which forms the basis of an OGC Innovation Challenge. These requirements prioritise local mobility and energy innovation in the British city of Manchester as part of its commitment to the Horizon 2020 Triangulum project.

Background

The Open Geospatial Consortium (OGC) CityGML modelling language has been successfully used in a number of city models in different parts of the world. OGC has been working on CityGML version 3 for some time, and the draft specification, publicly available on GitHub, is now ready to be validated at scale.

This Innovation Challenge is about configuring visualisation software tools to support the capabilities of CityGML 3. The resulting tools and visualisation environment, including the Manchester data, are to be made available for wider experimentation in mobility and energy innovation applications for a period of one year.

Our expectation is that:
- Visualisations will operate from a repository of CityGML data, butneed not be directly dependent on CityGML encodings such as GML.
- CityGML repository data will in turn be provided via one or more web services to visualisation clients in browsers, mobile devices, and augmented reality / virtual reality equipment.
- Dynamic data from sensor feeds will be loaded or directly accessed from Web APIs.

Ordnance Survey (OS), a strategic member of the OGC, is supporting Manchester City Council in the delivery of the Triangulum project (www.triangulum-project.eu) and is sponsoring this challenge on behalf of Manchester. OS has collated a range of data resources relating to the geography of Manchester's Oxford Road Corridor in the form of a CityGML 3 data model, which is a key input to the required visualisation tool and is described in the Annexe.

Requirements and priorities

1.   Visualisation priorities

The winning solution **must**:

    1.1.   Visualise a 2D (LOD 0) city model;
    1.2.   Visualise any 3D (LOD 1,2,3) data available in the same area;
    1.3.   Visualise 2D data overlaid on the city model;
    1.4.   Visualise time-series property data (e.g. air quality, noise) encoded as CityGML 3 "Dynamizer" objects, including 'slider' interaction to visualise change over time;
    1.5.   Allow for the visualisation of property data at different elevations, perhaps using a 'slider' for the z-dimension as well;
    1.6.   Provide users with a way to access metadata on city model objects and Dynamizer data, especially the time and date of data capture / recording.

The winning solution **should**:

    1.7.   Enable the visualisation of the local street environment via Google Streetview
    1.8.   Allow for the visualisation of data which is below the local surface of the ground (grade);
    1.9.   Support 3D visualisation of property data where the nature of that data makes it appropriate, e.g. air quality measurements at various elevations;
    1.10. Allow the user to select which dynamic data are to be visualised via APIs;
    1.11. Allow the user to import additional datasets for visualisation.

The winning solution **could**:

    1.12. Visualise building interiors, where model data are available;
    1.13. Provide fly-through visualisation of the city model.

2.   Data interface priorities

The winning solution **must** work with:

    2.1. The city data provided, including data modelled in CityGML 3;
    2.2. External APIs and datasets, the details of which are provided in the Annex, covering:

        a.   Air quality – as per local Air Quality Management Area datasets;
        b.   Energy consumption – data per building or building part;
        c.   Electric vehicle charging station data;
        d.   Cycle count data, concerning public short term cycle hire;

    2.3. In all cases, this must include the ability to query metadata about the dataset or feed;

2.4. External APIs referenced by CityGML 3 Dynamizer objects included in the city model.

The winning solution **should** work with:

2.5. Additional APIs and datasets, the details of which are provided in the Annex, covering:

- · Car park occupancy – provided in some cases as percentage occupancy and in others as number of vehicles against static capacity data;
- · Pedestrian count data – live from sensors, or modelled and historic;
- · Water level data for local canals and watercourses;

2.6. In all cases, this must include the ability to query metadata about the dataset or feed;

2.7. External APIs selected by users of the visualisation tool;

2.8. Additional data uploaded by users of the tool.

The winning solution **could** work with:

- · Data from Manchester's virtual power plant, covering the generation, storage and consumption of electric power at various facilities.

3. Architecture and platform requirements

The winning solution **must**:

3.1. Use cloud solutions where possible, to demonstrate scalability and wide access;

3.2. Allow augmented reality and virtual reality equipment to connect and visualise the data. This refers in particular to equipment available within the Manchester Triangulum project;

3.3. Allow the city data to connect to APIs using the CityGML 3 Dynamizer concept;

3.4. Allow the user to connect to APIs in order to load other dynamic data;

3.5. Allow the user to import additional data:

- o In OGC and mainstream GIS formats;
- o Including support for managing the semantics of that data – identifying feature types and identities in order to determine which features and properties to display, and in what way. *Note: it is assumed that there will be constraints on how the semantics must be described;*
- o With reporting as to constraints on data import and description of semantics;

3.6. Describe how role-based data access could be implemented in the tools and environment, so that access to some data would only be available to certain groups of users;

3.7. Allow suitably capable, OGC-standard GIS clients to access the city model via web services.

The winning solution **could**:

- · Allow the user to import data using either a pull or push mechanism;

· Provide role-based data access control, where certain data is only available to certain groups of users.

The winning solution **need not** provide any data export functionality

The winning solution **must not**:
3.1. Require any plugins or code, other than dynamic HTML + Javascript, to be downloaded for visualisation in a browser.
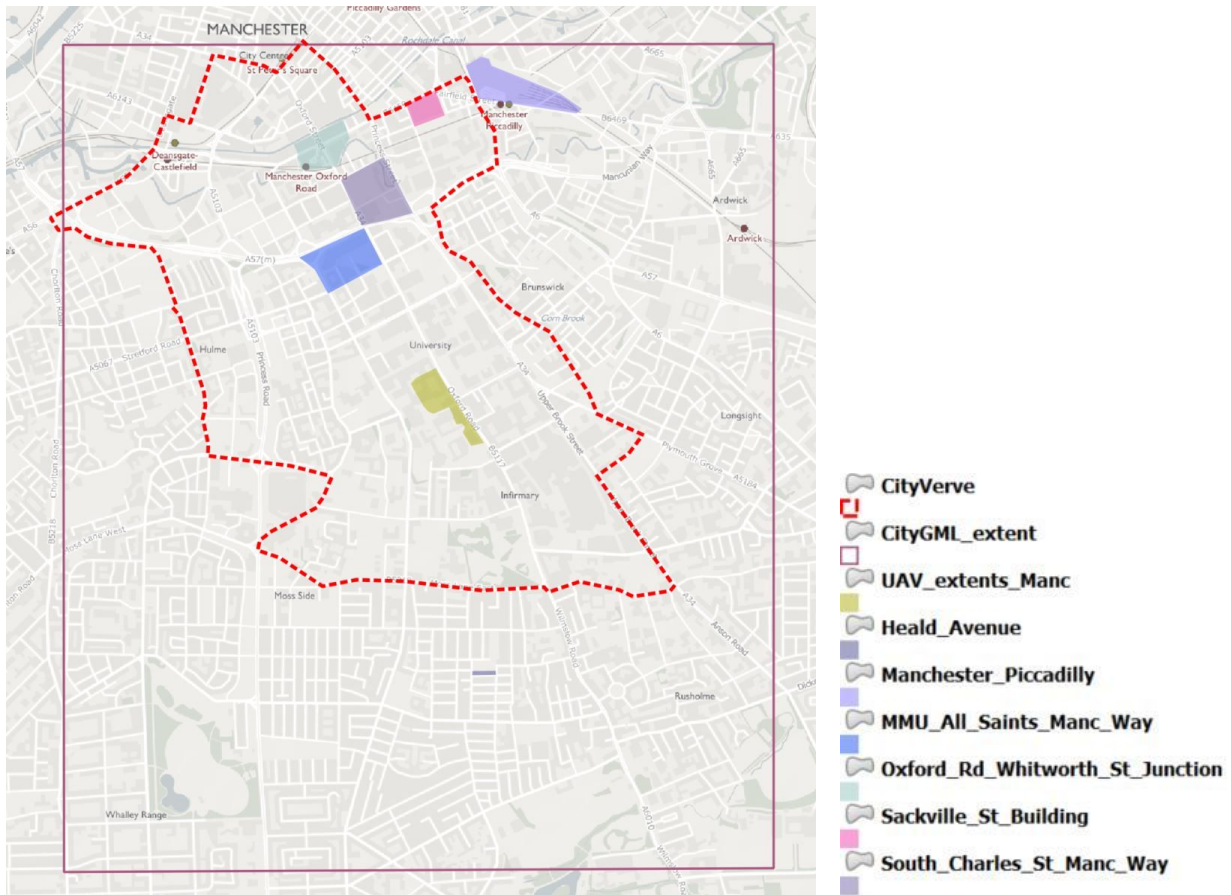
4. Non-functional requirements

The winning solution **must**:
4.1. Be available for at least one year under an open use licence allowing visualisation and exploitation of the web services for prototype and demonstration purposes;
4.2. Perform in a way that is compatible with a demonstration platform – that is, to enable a 'meaningful trial'. This means that views should refresh and respond reasonably under light loads;
4.3. Have online uptime and availability that is compatible with a demonstration platform – that is, to enable a 'meaningful trial'. The sponsors should be able to contact the supplier to ensure that specific planned demonstrations and events do not coincide with any planned downtime. The solution should otherwise be available for ongoing innovation trials;
4.4. Include provision of phone and email support during UK working hours;
4.5. Include simple online help documentation;
4.6. Host all of its data in Europe;
4.7. Comply with W3C web accessibility standards;
4.8. Comply with the European General Data Protection Regulation;
4.9. Incorporate the logos of the sponsors, Manchester City Council, Ordnance Survey, and the Open Geospatial Consortium.

# Annexes: Manchester datasets and API data feeds

Datasets

A variety of datasets are provided for the Oxford Road Corridor district of central Manchester, with extents illustrated below. These datasets and their extents are described in the following paragraphs.

CityVerve

CityGML_extent

UAV_extents_Manc

Heald_Avenue

Manchester_Piccadilly

MMU_All_Saints_Manc_Way

Oxford_Rd_Whitworth_St_Junction

Sackville_St_Building

South_Charles_St_Manc_Way

Ordnance Survey (OS) CityGML v3.0 LOD2 data for buildings

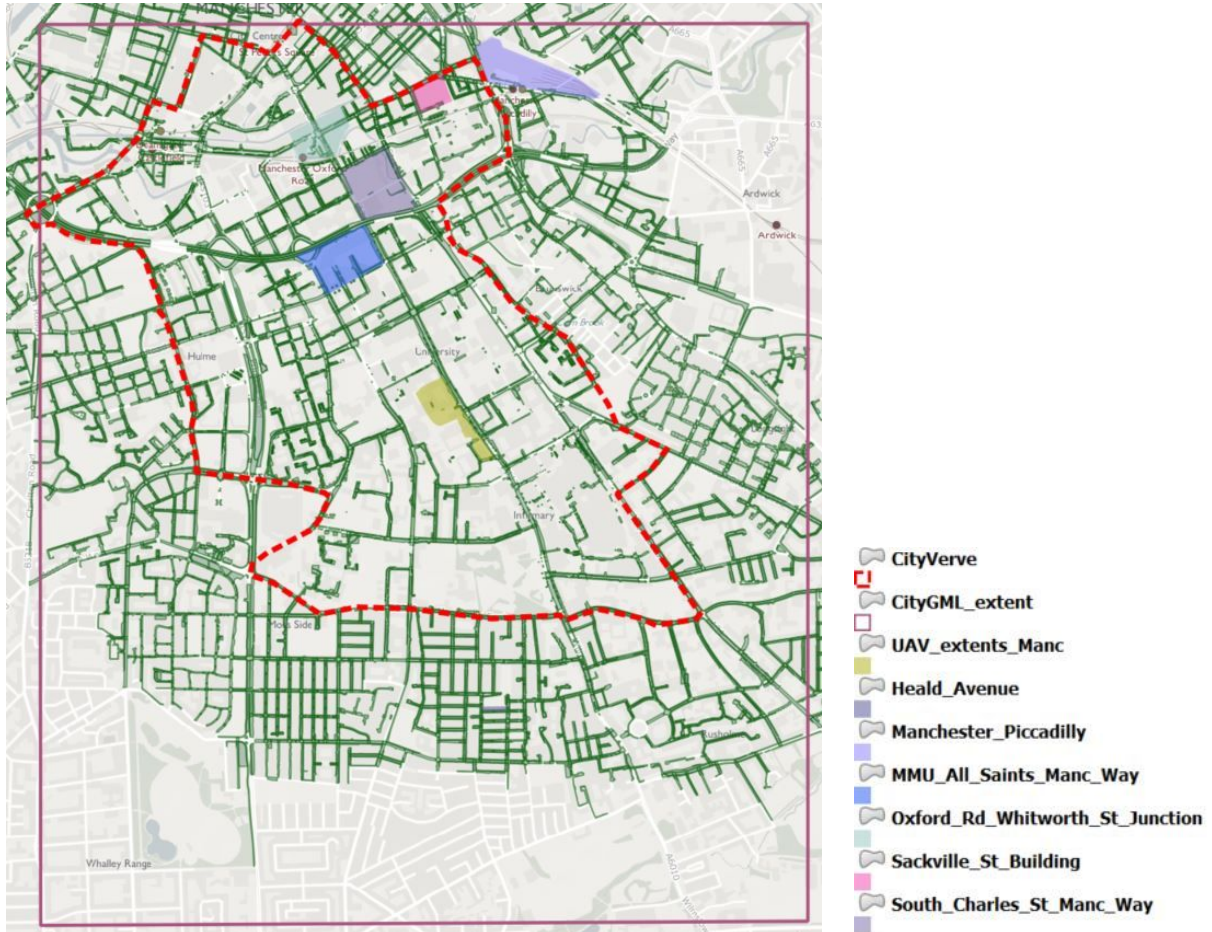The data covers all buildings within the outer *CityGML_extent* rectangle.

This data was automatically generated using Virtual City Systems software from aerial imagery captured with Ultracam XP and based on OS MasterMap Topography Layer building footprints. The image below indicates the extent of data created automatically (light brown) and areas which were also manually edited (orange).
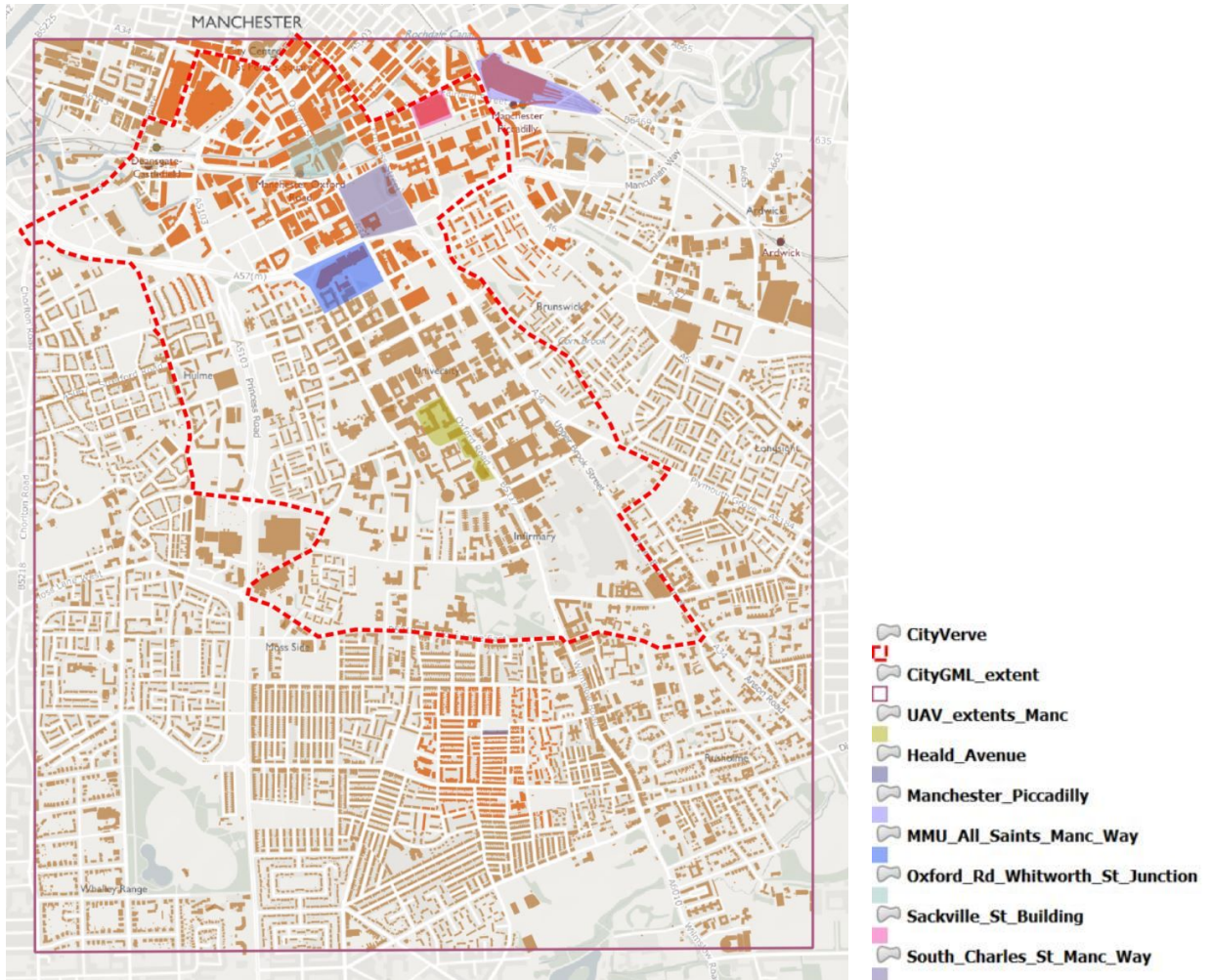
OS CityGML v3.0 data for traffic areas

The data covers all traffic areas within the *CityVerve* polygon.

The data was created based on OS MasterMap Topography Layer road polygon geometry (road surfaces, road side surfaces) and CityVerve street assets (data for which is provided separately as a file geodatabase and explained in the next paragraph).

Legend:
- CityVerve
- CityGML_extent
- UAV_extents_Manc
- Heald_Avenue
- Manchester_Piccadilly
- MMU_All_Saints_Manc_Way
- Oxford_Rd_Whitworth_St_Junction
- Sackville_St_Building
- South_Charles_St_Manc_Way

OS CityVerve street assets

Data is provided within the *CityVerve* polygon as a file geodatabase. It includes:

- Street assets line features (*street_asset_lines*), such as road markings, guard rails, dropped kerbs or advertising boards
- Street assets point features (*street_asset_points*), such as advertising posts, trees, road symbols, traffic calming features, obelisks, milestones, benches, bollards, cycle hiring points, cycle racks, lamps, bins, post boxes, parking meters, street signs, security poles and many more.
- Street assets polygon features (*street_asset_polygons*), such as tactile paving areas, bus stops, parking bays, box junctions, pedestrian crossings or railway level crossings.

OS 3D textured mesh tiles provided for 6 areas of interest (AOIs):

- Terraced houses (*Heald_Avenue*)
- Railway station (*Manchester_Piccadilly*)
- Manchester Metropolitan University (*MMU_All_Saints_Mancunian_Way*)
- *Oxford_Rd_Whitworth_St_Junction*
- *Sackville_St_Building*
- *South_Charles_St_Manc_Way*

OS Orthorectified imagery (geoTIFF tiles for the *CityGML_extent* polygon)

OS Digital Terrain Model

OS Terrain 5 product provided in SHP format as points and breaklines for the *CityGML_extent* polygon

OS Digital Surface Model

20 GeoTIFF tiles covering *CityGML_extent* polygon

OS Manchester UAV data

Data is provided within the *UAV_extents_Manc* polygon. It includes:

- Digital Elevation Model (DEM) in GeoTIFF format
- Orthorectified imagery - 3cm resolution in GeoTIFF format
- Mesh model in OBJ and FBX format
- Point Cloud in LAS format

API data feeds

A variety of live data feeds are also available, and are described below.

Manchester-I APIs - Manchester's data real-time data hub gathering information generated from Triangulum and CityVerve projects including:

- *Energy consumption* information for University of Manchester estates, such as A.V. Hill, Alan Gilbert, Alan Turing, Barnes Wallis, Chemistry, Christie, Ellen Wilkinson, George Begg, Humanities Bridgeford, Manchester University Library, Stopford, Zochonis. Data includes half-hourly electricity consumption readings (kWh), CO_2 emissions due to electricity consumption (kg), gross internal area (m2), consumption per unit of area (kWh/m2), net internal area (m2) - source of data: University of Manchester;

- *Transport and mobility*
  - *Car parks* - information about car parks located in Manchester - capacity, free spaces, occupancy and state information in 1 minute intervals - source of data: TfGM;
  - *EVs charging sessions and journeys* - information about a distance, CO_2, CO, NOx, PM not emitted; start, end and duration of journey - source of data: University of Manchester and Manchester Metropolitan University;
  - *Cargo bikes* - information about the usage of cargo bikes in Manchester - journeys data for 11 cargo bikes - distance, CO_2, CO, NOx, PM not emitted; start, end and duration of journey - source of data: Manchester Bike Hire;
  - *Charging Stations* - information about charging events - charge, cost, start time - timestamp for the session's end time - source of data:Charge Your Car;

  - *Air quality* - air quality measures for monitoring stations in: Piccadilly Gardens, Oxford Road (All Saints' park), Whitworth Meteorological Observatory, Bury Prestwich, Bury Whitefield Roadside, Salford Eccles, Salford M60, Stockport Cheadle, Stockport Hazel Grove, Trafford, Trafford A56. Data consists of readings for levels of NO, NO2, O3,NOx, PM 10, PM 2,5, SO2 in 1 hour intervals for DEFRA and 1 minute intervals for University of Manchester;

  - *Rivers level* - information about water level (m) measured in a number of keypoints across the river and canal system of Greater Manchester in 24 hours intervals - source of data: Flood information service.

  - *Weather* - data collected from the Whitworth Meteorological Observatory, including readings for: cloud base, cloud cover, dew point, optical range, precipitation range, preasurre, relative humidity, solar radiation, temperature, wind direction, wind speed - source of data: University of Manchester

  - *Pedestrian counts* - source of data: Retail Sensing. **NB data feed still in preparation.**

Integrated file geodatabase

We have provided an additional file geodatabase (called *File geodatabase (OS products +MCR-I +TfGM)*)) which includes:
- **Ordnance Survey product data** (please follow the link for more information about the products below):
  - OS MasterMap Topography Layer
  - Boundary-Line
  - OS MasterMap Water Network
  - OS MasterMap Highways Network
  - Code-Point with Polygons
  - Points of Interest
  - OS MasterMap Greenspace Layer
  - AddressBase Plus
- **Manchester-I** sensor location data with link to APIs (as above)
- **TfGM cycle counters** data 10 locations within Greater Manchester (4 within Oxford Road Corridor)
- **Virtual power plant** - average energy consumption readings over a 30 minute window for Town Hall, Central Library, All Saints and Business School - source of data: MCC and MMU. **NB Data in preparation.**

The table below summarises the information for each of the feature classes provided within this file geodatabase.

data source	data name	description
MCR-I data	air_quality_station	air quality measures for monitoring stations
	car_parks	car parks location
	cargo_bikes	usage of cargo bikes
	ev_charging_station	information about charging events
	ev_journeys	duration of the EV journeys
	river_level	river level monitoring stations
	utilities	Energy consumption
	weather_station	weather monitoring at Whitworth Meteorological Observatory
TFGM	acc_sites	cycle counters for 10 locations within Manchester, Transport for Greater Manchester cycle counter sites with monthly summaries for Jan-Jun 2019
	acc_hourly_totals	Transport for Greater Manchester cycle counter hourly totals for 4th June
OS Products	topographic_area	OSMM TopographicArea - Basic attribution (descriptive group and term) for OS Topographic Area
	ward	OS Boundary Line and ONS lookup data - ONS political ward boundaries
	watercourse_link	OSMM Water Network - Individual water links from OSMM Water Layer
	street	OSMM Highways (Road) - Higher level street information from OSSM Highways data (does not include cross references to road links)
	road_link	OSMM Highways - Individual road links from OSMM Highways data - Postcodes and cross-references to the ONS output area, LSOA, MSOA, ward and parliamentary constituency that contains them
	postcode	OS Codepoint Polygons - Postcodes and cross-references to the ONS output area, LSOA, MSOA, ward and parliamentary constituency that contains them
	functional_site	OS Functional Sites - Location of OS Functional sites
	access_point	OS Access Points (for Functional Sites) - OS points of access to OS functional sites
	greenspace	OS Greenspace - location of OS Greenspace sites
	lsoa	OS Boundary Line and ONS lookup data - ONS Lower Layer Super Output Area statistical boundaries, with cross reference to MSOA that contains them
	msoa	OS Boundary Line and ONS lookup data - ONS Middle Layer Super Output Area statistical boundaries
	output_area	OS Boundary Line and ONS lookup data - ONS Output Area statistical boundaries with cross references to LSOA and MSOA that contain them
	parliamentary_constituency	OS Boundary Line and ONS lookup data - Location of parliamentary constituencies
	points_of_interest	OS Points of Interest - Basic address information with cross-references to ONS statistical output areas
	address	OS AddressBase - address information

API guidance

Manchester-I is hosted on the PI Web API service and documentation for this service can be found here https://vm-pi-p02.ds.man.ac.uk/piwebapi/help

Here is an example of using the API through the utilities file in the file geodatabase.

- The URL field gives a list of the available streams at that location
- The Electricity, heating, net_internal_area, water, co2_electricity, kwh_perm2_net_area & gross_internal_areas fields contain urls which bring the individual sensor streams
- If you click on this electricity stream you get all of the current info for that stream:
  ```
  {
  "Timestamp": "1970-01-01T00:00:00Z",
  "Value": 0.0,
  "UnitsAbbreviation": "kWh",
  "Good": true,
  "Questionable": false,
  "Substituted": false
  }
  ```

- If you then add ?selectedFields=Value to the end of the url you get (documentation https://vm-pi-p02.ds.man.ac.uk/piwebapi/help/topics/selected-fields)

  ```
  {
  "Value": 0.0
  }
  ```

  This works for any field so ?selectedFields=UnitsAbbreviation
  You get:

  ```
  {
  "UnitsAbbreviation": "kWh"
  }
  ```