# Coding spatial referencing for Digital TROs

## Discussion Paper – Version 2

## 1 Introduction

The Department for Transport (DfT) through a series of projects has been developing a Data Specification to support the encoding digitally of Traffic Regulation Orders (TROs).

At the time of writing, DfT have commissioned a Beta project to deploy a candidate national central service for digital TROs (known as D-TRO). This is being delivered by PA Consulting.

Further information on D-TRO is available from the Transport Technology Forum website.

One of the technical aspects within the D-TRO Beta Data Specification which requires further clarification and resolution, is how to systematically encode information relating to the spatial location and positioning used within TROs.

This paper lays out some of the considerations and a standardised approach.

It is designed to provide details of the standardised approach, highlight some open points of discussion and form the basis for agreement with stakeholders.

This version of the paper has taken account of the review and consultation undertaken with Traffic Regulation Authorities (TRA) and several digital software service providers. The standardised approach has been modified to take account of feedback received.

The approach will shape the data structures that are needed to support it within the D-TRO Beta Data Specification and its Data Model.

## 2 Why is this needed?

Why do we need to detail how TRO locations should be coded?

- There is no agreed convention on how to do this.
- Many existing TRO use textual (human-oriented) descriptions of the locations to which they apply. Machine interpretation of textual location descriptions is a challenging and error-prone process. The common adoption of primary location descriptions being defined by agreed forms of spatial coordinates is a more robust approach for ensuring the accuracy and interoperability of digital TRO data in the future.
- Where map-based TRO information is available there are examples of diverse practice in use by TRA. Some TRAs represent speed limits as road centreline/reference linear features, other use polygons; multiple different representations of kerb-line restrictions for parking, loading and waiting can be seen.
- Simply coding TRO locations as spatial coordinates as a combination of elemental spatial features (points, lines and polygons) obscures what these are meant to represent, which makes the data harder to use and process by data consumers. Hence, we need to have a consistent approach and convention about how to use these elemental spatial features.

## 3 Design Considerations

### 3.1 General Considerations

- In order to make future digital TROs useable to the widest set of stakeholders and applications the provision of a coded location that is machine-interpretable and can be

related to specific spatially coded locations on digital maps is considered essential. Following stakeholder comment, DfT has revised the proposed recommended approach. Given the need to reduce barriers to uptake during the D-TRO Beta project phase, no singular preferred approach is mandated. Therefore, for example, a speed limit TRO provision can be represented either by linear road centreline/reference line features (polyline) or by use of a polygon. Similarly, kerb line regulations can be represented as a polyline, a polygon or both. This approach will be reviewed during the D-TRO Beta project, taking on board feedback primarily from data consumers concerning the useability of mixed approach data. DfT continues to prefer the use of polygons, but these are not mandatory.

- Some forms of TRO do require special treatment to ensure that the data can be correctly interpreted. This special treatment applies to:
  - Gate/point locations
  - Directional regulations (such as no entry, one-way streets, turning movements, etc.)
- There is a need to provide clear guidance and a common approach to enable TRAs to code TRO locations.
- Single consolidated or other TROs may represent a range of measures (Provisions) impacting different locations - this approach should support TRAs to identify and code regulated locations in a manner that they consider appropriate. The approach aims to limit specific coding rules to a practical minimum, enabling both alignment with the more commonly used existing practice whilst counter-balancing use of a limited number of coding mechanisms which will aid greater commonality and interoperability of data.
- In general, if a TRO regulation is identified as being effective at two or more distinct locations, each location should be treated as a separate "regulated place", as laid out in the D-TRO Data Specification.
- The design approach aims to address the wide spectrum of different forms of shape that TRO regulations can take.
- The standardised approach:
  - should not be tied to a specific form of reference base map data set.
  - shall use a widely understood and supported standardised data format.
  - should be cognisant of the level of effort required to achieve it.
  - should support the needs of identified use cases, so far as these are defined.
  - should separate the principles of what is being encoded, from the actual IT-centric coding mechanism itself.
- There is no support in the D-TRO Beta Data Specification to enable the upload of scan or electronic version of TROs, schedules, or associated maps.

## 3.2 More detailed considerations

The following outlines more detailed considerations that also shape the nature of the standardised approach:

- Common practice – how close is this approach to what is done already? There is no agreed existing standardised approach, but common patterns of approach can be seen. Migration to a standardised approach will require several forms of change:

- Awareness and education amongst the TRAs' operational staff who are defining and codify the detailed of TROs;
- Promotion of the standardised approach amongst software and service providers, to enable software solutions to offer tools to code TRO data in a manner that is compliant with the standardised approach;
- Awareness and education amongst data consumers concerning the standardised approach and how this is represented in compliant encoded data.

— Flexibility – lots of different physical configurations of TRO measures occur in the real world – the standardised approach needs to establish common ways to encode locations – using a limited number of different approaches but in a way that enables the spectrum of real-world shapes to be appropriately and consistently encoded.

— The standardised approach should contain essential data, with limited additional (optional or conditional) data. Essential data will include geometric spatial coordinates to enable the physical TRO shape to be defined, and the coordinate referencing system that is used to express these coordinates, and when this geometric shape was specified.

— Coding directionality - some TROs are sensitive to and applicable for particular directions of movement (e.g. one-way streets, no entry, etc.)

— The need and associated cost of provision of additional contextual information that may either reduce the risk of mis-translation of the source location information when consumed by a data consumer – by, for example:

- providing both spatial coordinates for the TRO measure geometry but also street names/road numbers that this occurs on;
- linkage to a well-known public road network model data set (such as USRN/ESUs and street names or numbers within the National Street Gazetteer).

— In a limited number of cases, it is not sufficient to define the shape of a TRO using only 2D coordinates, such as longitude/latitude, or Northing/Easting, as some roads subject to TROs are only displaced by vertical separation (examples, roads running above a road tunnel, grade separated roads and intersections).

— Different use cases for the use of TRO data are likely to have different accuracy requirements. Recognition is made that existing practice for mapping TROs during creation such as within a third-party software system for managing TROs and using, perhaps, Ordnance Survey supplied data as a baseline reference, has inherent limitations in terms of defining precise locations. It is expected that future empirical evidence and use of the D-TRO data will better inform more detailed accuracy requirements. For the purposes of the D-TRO Beta project Data Specification a tolerance of no more than 2 metres from real-world locations shall be permitted.

Note: The following is noted: *From NSG Data Entry Convention: taken from BS 7666-1:2006 – "all coordinated points shall be measured to an accuracy of not less than 10 m relative to other recorded coordinates, and recorded at a precision of 1 m."*

*Expected scale at production – probably scale 1:1250 (1cm = 12.5m) in the urban area… As a general guide, the width of a line on a 1:1250 Ordnance Survey map roughly represents 0.3 metres on the ground.*

— There are choices of options to be made concerning both:

- **The coordinate referencing system**

  The form of spatial coordinates (and coordinate reference system) that position the coordinates to be used. Consideration has been given to alternatives.

  The OSGB36 / British National Grid Coordinate Reference System (ESPG:27700) shall be used.

  OSGB36 is well aligned with other local authority data obligations (NSG, LLPG) and provides a baseline CRS that is anchored on the UK.

- **Format of coding of geospatial information**

  The specific form of standardised data encoding to be used to structure TRO location data in a way that is consistent robust and commonly interpreted. Use of both GeoJSON or WKT [Well Known Text] conventions have been considered. However the latest edition (2016) of GeoJSON (RFC 7946) only permits the use of WGS84 coordinates, and therefore cannot be used given the coordinate referencing system decision above.

  Coding of geometric data shall conform to the WKT standard ( ISO/IEC 13249-3:2016).

## 4 Forms of shapes/geometries of TRO regulations

A TRO may contain multiple distinct regulations (measures) which relate to potentially numerous Regulated Places. The shape/geometry of the spatial footprint of a Regulated Place may not be well defined in existing and current new TROs.

Table 1 provides an overview of the forms of shape/geometry for TRO regulations:

| | |
|---|---|
| **Section of whole road**<br>(e.g. speed limit, one-way street) | **Lane-based**<br>(e.g. bus lane restrictions, HOV lanes) |
| **Point/gate**<br>(e.g. bus gate, width access control) | **Zone/Area (polygon)**<br>(e.g. Controlled Parking Zone, 20 mph speed limit zone) |
| **Section of kerb line**<br>(e.g. parking/loading restrictions) | **Turning movement**<br>(e.g. banned turns) |

*Table 1 - Different shapes of TRO locations*

## 5 General Approach (Proposed - Revised)

The following sections lay out a standardised approach for how the location data for TRO regulations should be handled.

All TRO regulation measures shall be defined geospatially, using coordinates, and coded in WKT format.

The standardised approach covers general concepts, such as where to place spatial polygons or polyline in different circumstances, which is expected to be appropriate for most forms of TRO regulation – see section 6 below.

The standardised approach addresses:

- instances where TRO regulations are subject to a direction, such as one-way streets, no entry restrictions, banned turns etc. – see section 5.1.
- cases where TRO regulations may apply to roads that appear coincident on a map but are grade separated vertically – see section 5.2.
- the topic of providing additional contextual information that enables the TRO regulation locations to be associated directly with references found in well-known road network model data sets, specifically the National Street Gazetteer – see section 5.3.
- other forms of TRO regulation location which can be considered more point-like – see section 7 below.

## 5.1 Directional and turning movements regulations

Some TRO regulations are applicable in specific directions (e.g. one-way streets, no entry restrictions, bus lanes for specific directions, but also turning movement restrictions or obligations). The use of polygon representations does not reliably support a clear and unambiguous sense of a directional regulation that may apply (i.e. polygons do not normally have a start and end and a sense of direction).

Where a directional regulation or turning movement regulation is present a directional polyline[1] (an ordered sequence of coordinate pairs) should be specified. The first coordinate pair in the sequence indicates the origin – the start of the direction flow for restriction. The last coordinate pair in the sequence indicates the destination – the end of the direction flow for the restriction.

In exceptional cases, the simple definition of an origin and destination may not uniquely and unambiguously definition a path. In such cases, a third or further additional coordinates pairs may be inserted in the sequence to create uniqueness. Example, defining a one-way directionality around a closed loop would require at least 3 coordinates pairs (such as a roundabout)).

The origin and destination coordinate pairs should align with the notional centreline of the lane (or group of lanes) in the effected directions of the origin and destination road.

Differentiation of the positioning of the origin and destination coordinates for the directional polyline shall be sufficiently discrete to support the appropriate identification of affected road sections.

*Discussion point: are more specific rules concerning the positioning of the origin and destination coordinates for the directional polyline required? In a similar manner to the NSG-DEC requirements?*

[1] Note: polylines are referred to as linestrings in WKT.

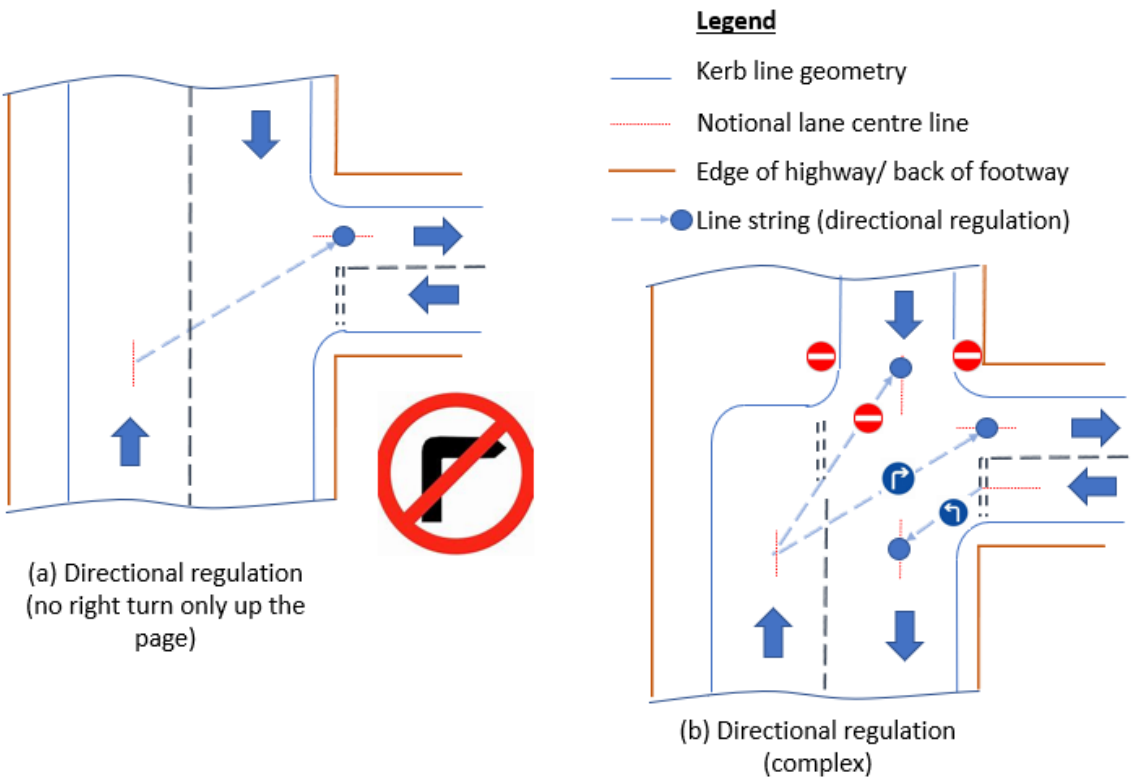



*Figure 1 - Polyline definition of a directional regulation*

Example of directional polyline definition for a one-way street (courtesy of Bedford Borough Council):

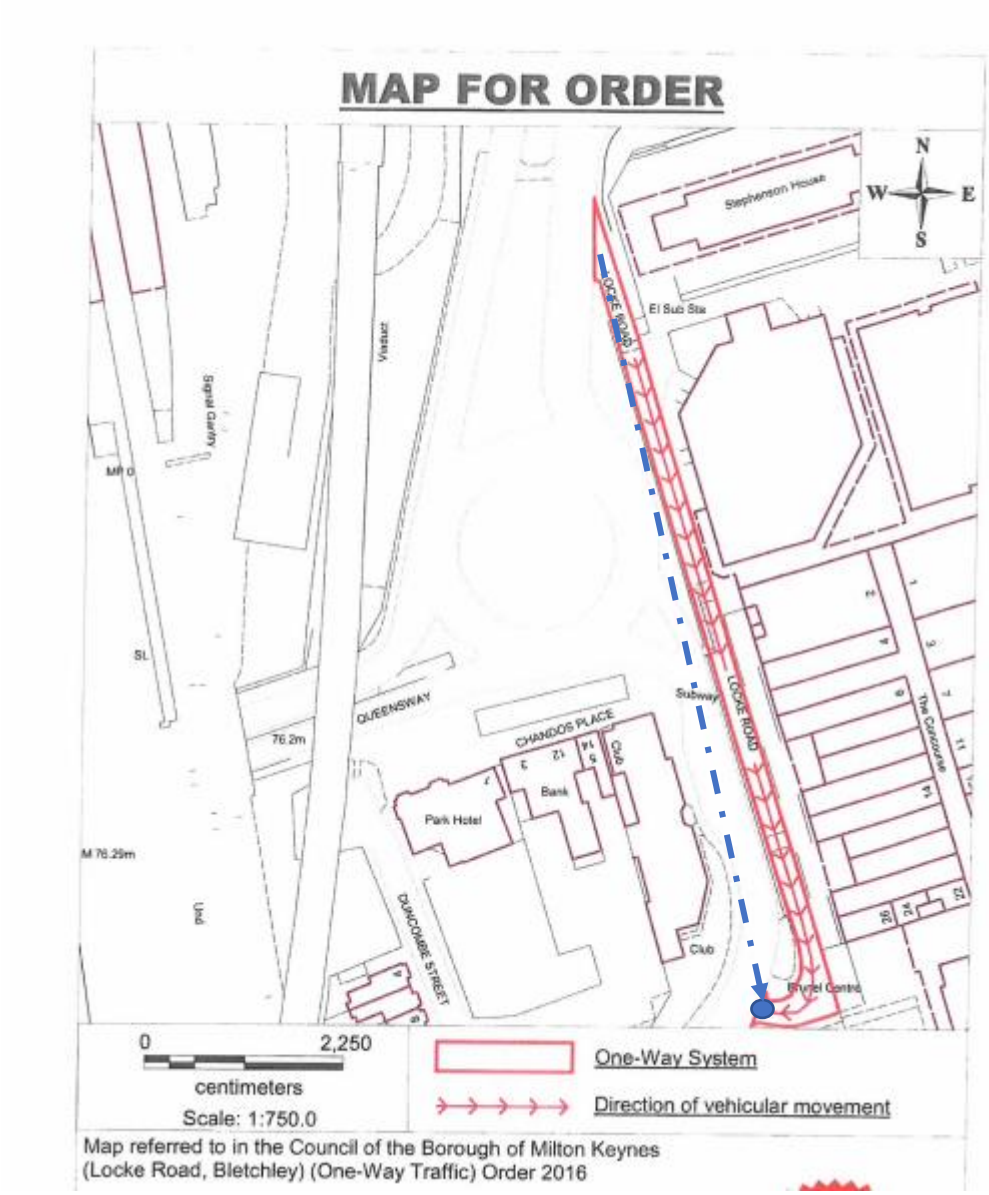



*Figure 2 - Linestring definition of a directional regulation (one-way street)*

External references made to the National Street Gazetteer shall identify the origin and destination road sections (both USRNs and ESUs shall be supplied).

Additional references are discussed in section 5.3 below.

## 5.2 Vertical distinction

In a limited number of cases, it is not sufficient to define the shape of a TRO regulation using only 2D coordinates where roads are vertically aligned.

Examples are TRO regulations that exist on roads running above a road tunnel, or in the road tunnel itself, or grade separated roads, such as the A40 Westway, M4 and A4 sections in the west of London and grade separated links within intersections.

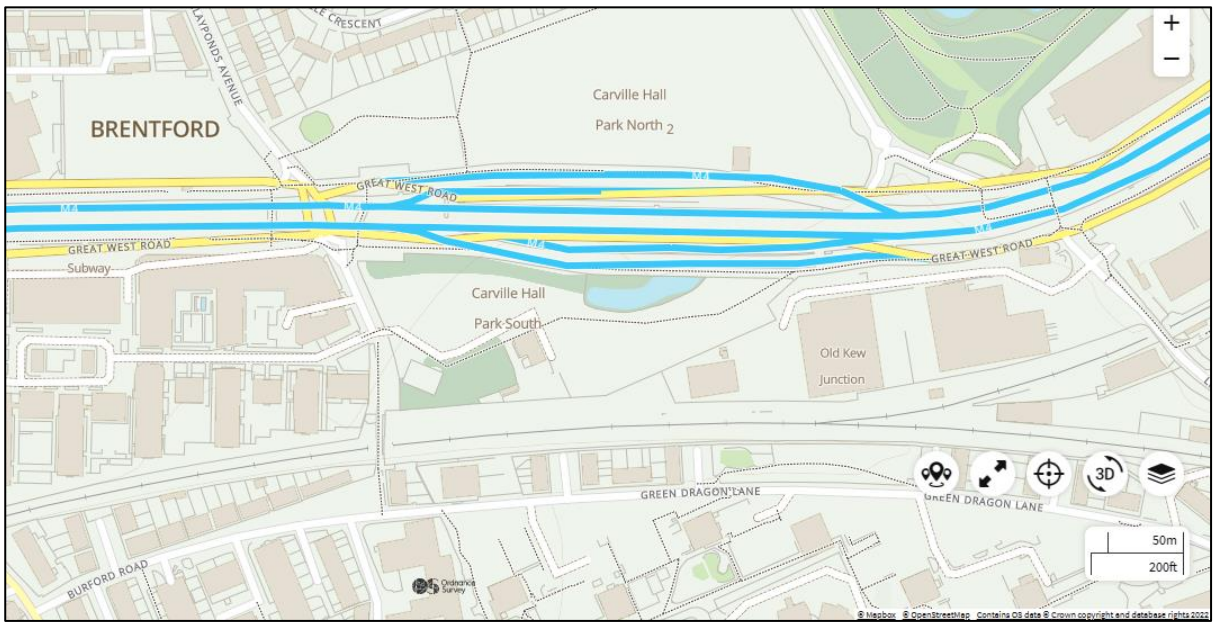



*Figure 3 – Illustration of grade separated co-located roads (M4 / A4 West London) – Courtesy of OS/Mapbox*

When required, the spatial coordinates used to define geometries can be extended from 2D to 3D.

For example, when using the WKT (Well Known Text) coding convention, coordinates for geometries may be 2D (*x*, *y*), 3D (*x*, *y*, *z*), or even 4D (to support linear referencing). Three-dimensional geometries are designated by a "Z". With our approach 2D and 3D geometries are supported.

## 5.3 Links and external references

There is interoperability benefit and inherent redundancy for TRO data if references to well-known road network model data sets are made for TRO regulations. This reference link enables a TRO regulation to both spatially and contextually positioned. Although there are potentially many well-known road network model data sets that could be linked to, many of which are supplied on a commercial basis.

For the purpose of this approach, it is proposed that the external reference to be used shall be to the National Street Gazetteer (NSG). This conforms to HM Government policy.

*Discussion point: It has also been requested that the NSG street name and/or number should also be provided to aid matching. For the current D-TRO Beta Data Specification this requirement has been added.* It is noted that not all roads are contained in the NSG, and therefore inclusion of USRNs cannot be mandatory in all cases.

# 6 Polygon and polyline coding

## 6.1 Polygon coding

Guidelines:

Define a coordinate-polygon that represents the extent of the road subject to the TRO regulation.[2]

[2] The extent of the polygon representation is a topic worthy of wider review. Should a spatial representation of a Regulated Place correspond to how this is presented to the public (for example, as a restriction along a kerb line) or represent the full extent legally that is the subject of the specific regulation in that Regulated Place (for example, extending to the rear of the footway, or edge of the Highway)? The data model could support either option, or both.

The guidance divides the forms of TRO shapes into the following:

- Whole sections of road (full width)
- Regulations with bounding marking
- Regulations with partial marking

## 6.2 Whole sections of road (full width)

*This typically applies to regulations specified for whole sections of road (e.g. speed limits, zonal height/weight/width limits, etc.)*

Polygons shall be defined for the regulated extent of TRO regulations.

Differentiation can be made between:

- consultation proposals – where locations are indicative (and purposed for map rendering representation for public consumption).
- Plans for making of regulations (or for construction).

### 6.2.1 Consultation proposals

Polygons may be sub-divided as required, so long as the union of these provides full coverage of the spatial location of the intended regulation.

See example, Figure 4 (courtesy of Transport for London)

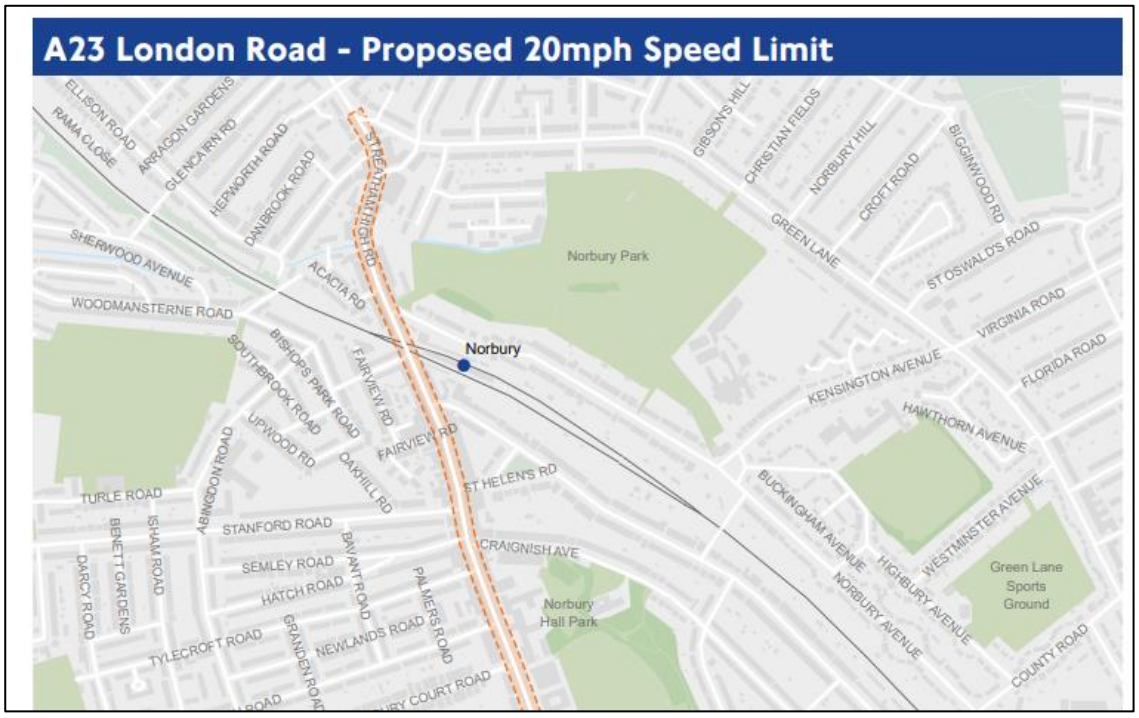



*Figure 4 - Example of indicative polygons for consultation proposals*

### 6.2.2 Plans for making of regulations (or for construction)

Polygons shall be established to represent the physical extent of the regulation. These should extend (laterally) to the back of footway or edge of the Highway if that is the coverage of the regulation. These should extend and be terminated at the intended location of terminator traffic signs indicating the presence of the regulation.

Examples below, Figure 5 and Figure 6 (courtesy of Transport for London):

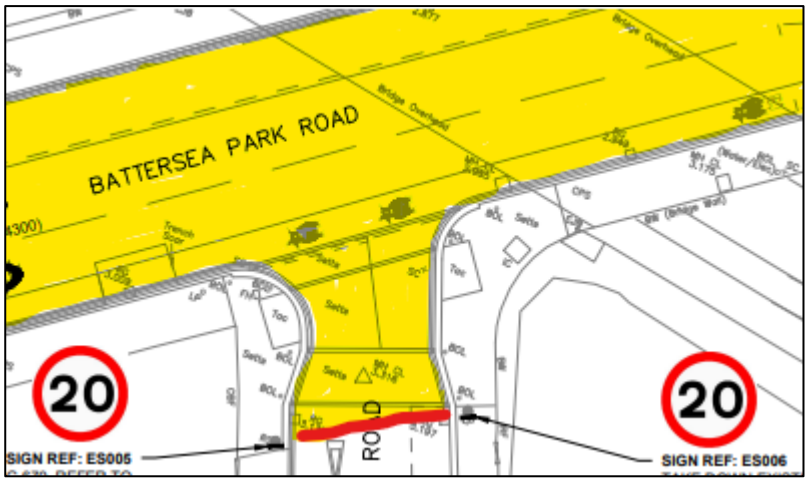



*Figure 5 - Polygon definition for Made TRO - example 1 (side road)*

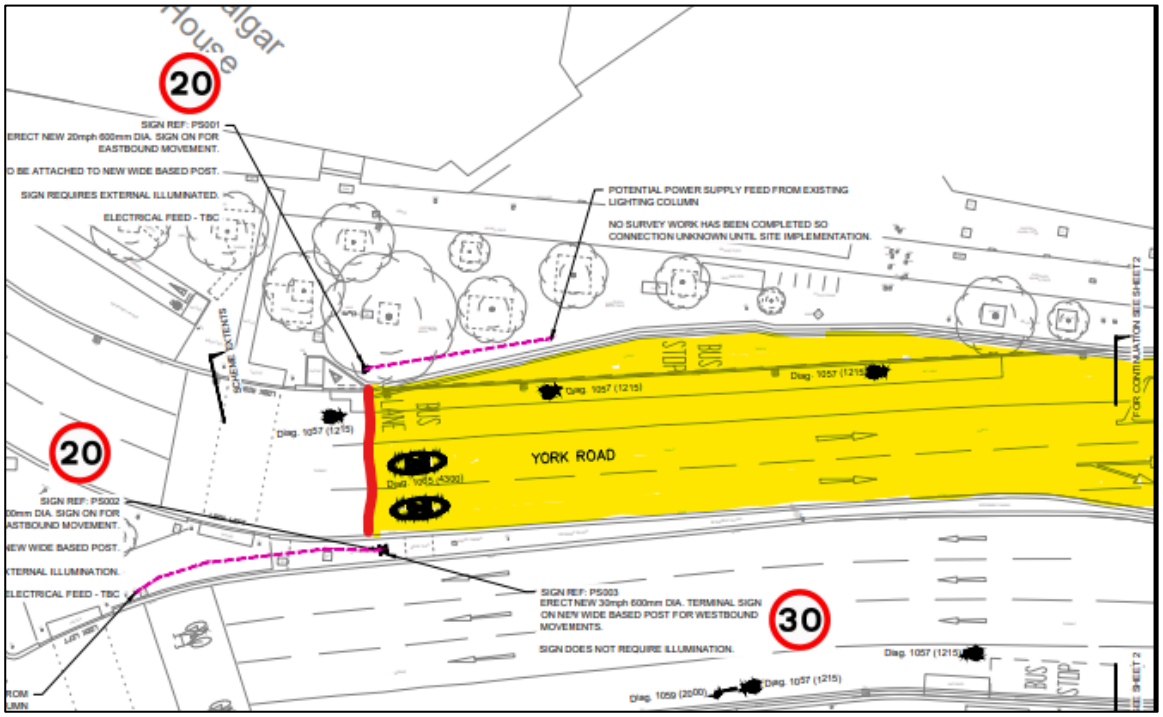



*Figure 6 - Polygon definition for Made TRO - example 2 (whole road - multiple lanes)*

The terminal positions shall be specified to a position not more than 2 metres from the expected site of terminal signs.

If the position of terminal signs is unknown on side roads, the polygon should be defined to the back of the footway on the major road.

### 6.2.3 Regulations with bounding marking

| |
|---|
| *This typically applies to regulations related to marked and indicated lanes, bays, lay-bys, cycle tracks, etc.* |

Polygons shall be established to represent the physical extent of the regulation. These should extend to indicated markings. See Figure 7 for an example.

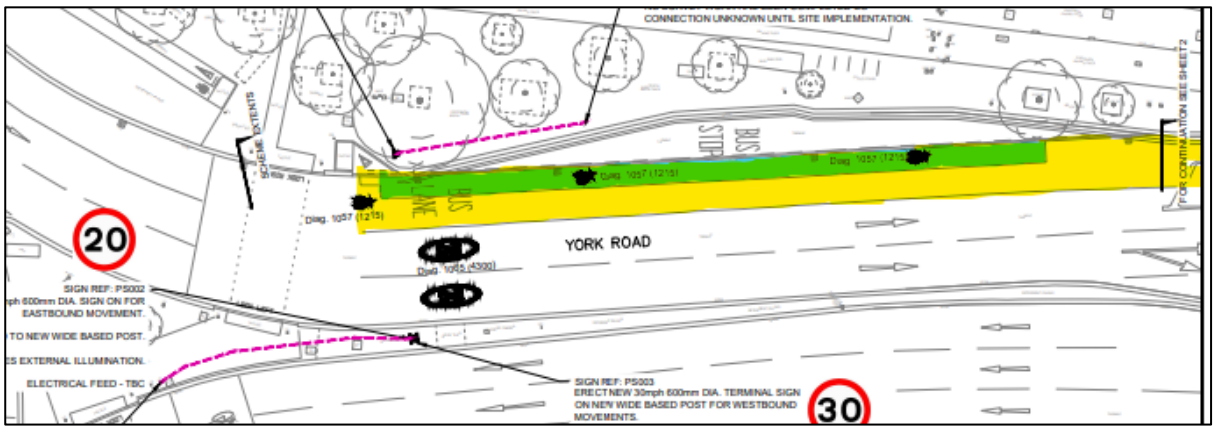



*Figure 7 - Polygon definition for Made TRO - example 3 (specific lane, specific marked lane/area)*

### 6.2.4 Regulations with partial marking

> *This typically applies to kerb side regulations which are indicated by kerb side marking with no marked bays*

Polygons shall be defined for the regulated extent of TRO regulations.

For kerb side regulations (that extend to back of the footway) the representative polygon shall be the longitudinal extent of the regulation and laterally from the back of the footway to either:

- The marked centreline, if present, for a two-way road, or
- The notional centreline of the road, if no marked centreline is present.

Example illustrations are given below:

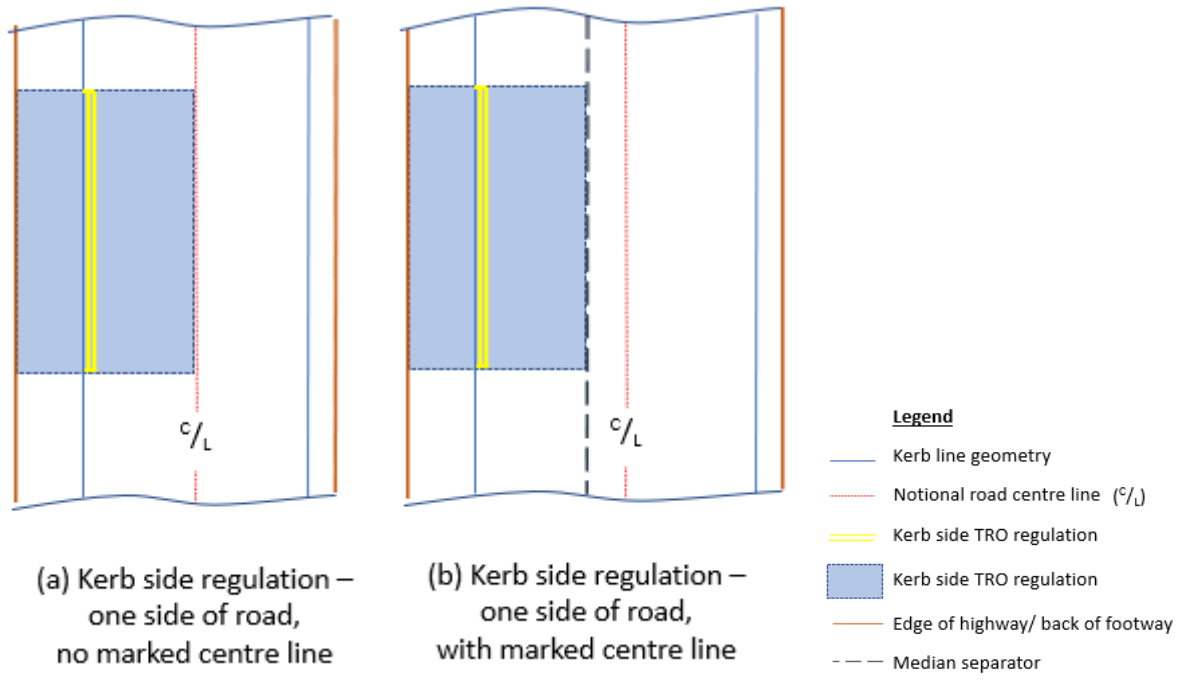



*Figure 8 - Polygon definition for Made TRO - example 4 (partial marking)*

Example (courtesy of Bedford Borough Council):

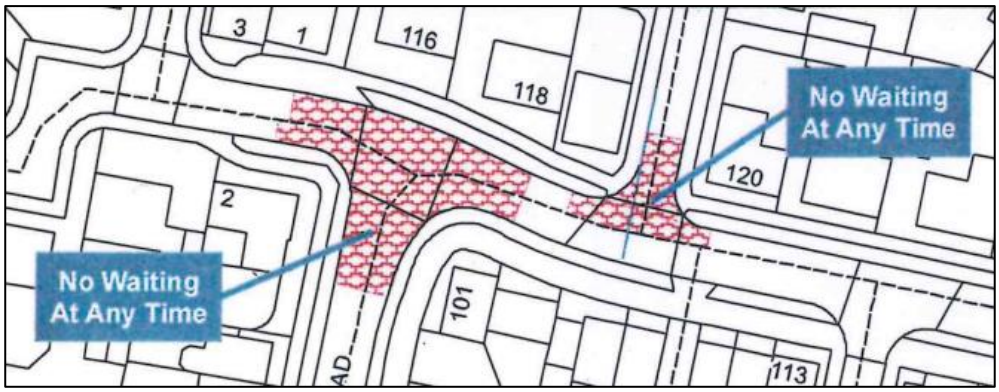



*Figure 9 - Polygon definition for Made TRO - example 5 (partial marking)*

Polygons can also be used to define regulated zones.

See example below (courtesy of Bedford Borough Council)

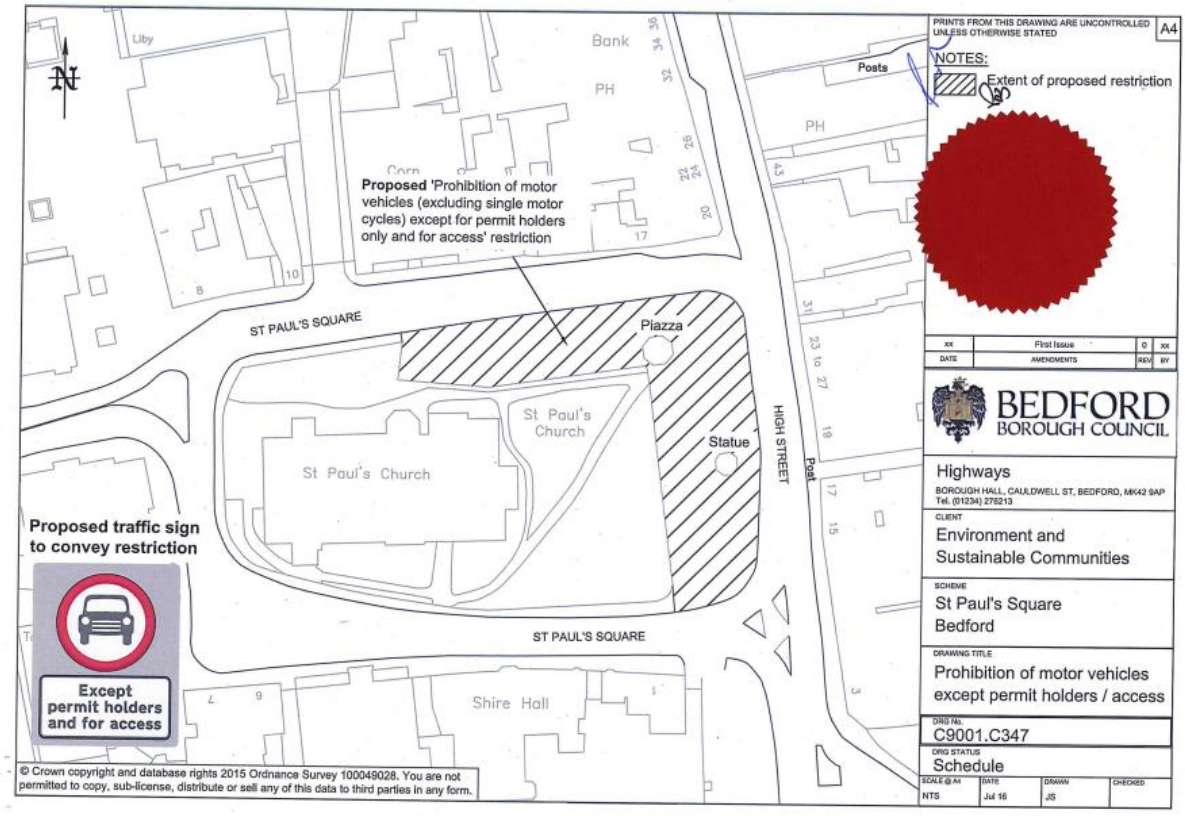



*Figure 10 - Polygon definition for Made TRO - example 6 (partial marking)*

## 6.3 Polyline coding

Polyline coding can, alternatively, be used to specify the linear extent of a regulation. It is essential that metadata is supplied that indicates what the polyline represents, and information about its lateral offset.

# 7 Gate/point locations

*This typically applies to "gate" type regulations which regulate the movement of traffic at a point location on a road (e.g. bus gates, limited width barrier, etc.).*

A point or polyline or polygon representation is used to represent such TRO regulation locations. Point representations are preferred.

If used, a point can be established to represent the approximate mid-point of the regulation.

If used, a polygon can be established to represent the physical extent of the regulation.

The polygon shall extend not less than 2 metres along the longitudinal axis of the road.


*Figure 11 - Polygon definition a gate-like TRO regulation - example 7 (provenance unknown)*

# 8 Location Referencing in the current D-TRO Data Model

## 8.1 Previous DTRO Data Model Release – Location Referencing

Figure 12 below is an extract from the latest release of the Digital TRO (D-TRO) Data Model, version 3.1.1, published June 2023. At the time of publication, it was noted that this subsection of the overall D-TRO Data Model would be subject to revision – as a result of the publication of this paper and subsequent stakeholder agreement.

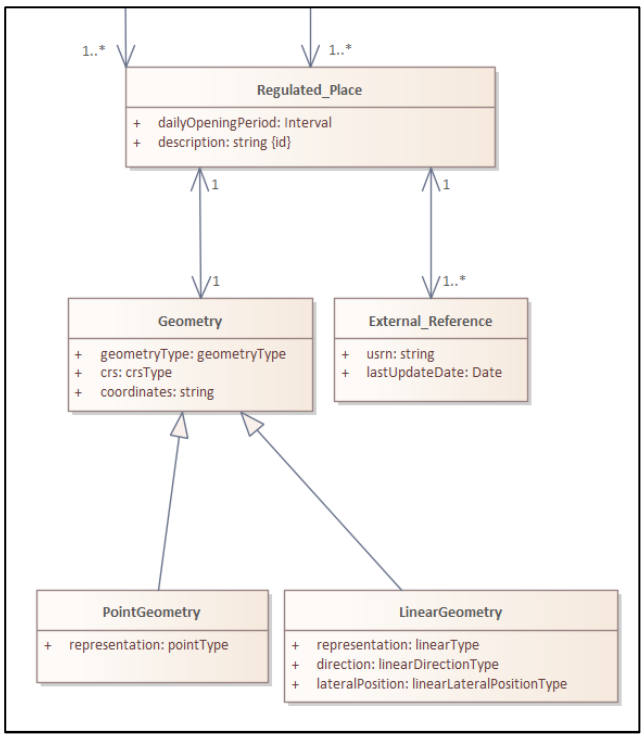



*Figure 12 - Existing D-TRO Data Model structures for Location Referencing – Released January 2023*

## 8.2 Proposed DTRO Data Model update – Location Referencing

Figure 13, below, provides the class diagram representing the data structures required to support the approach outlined in this paper.

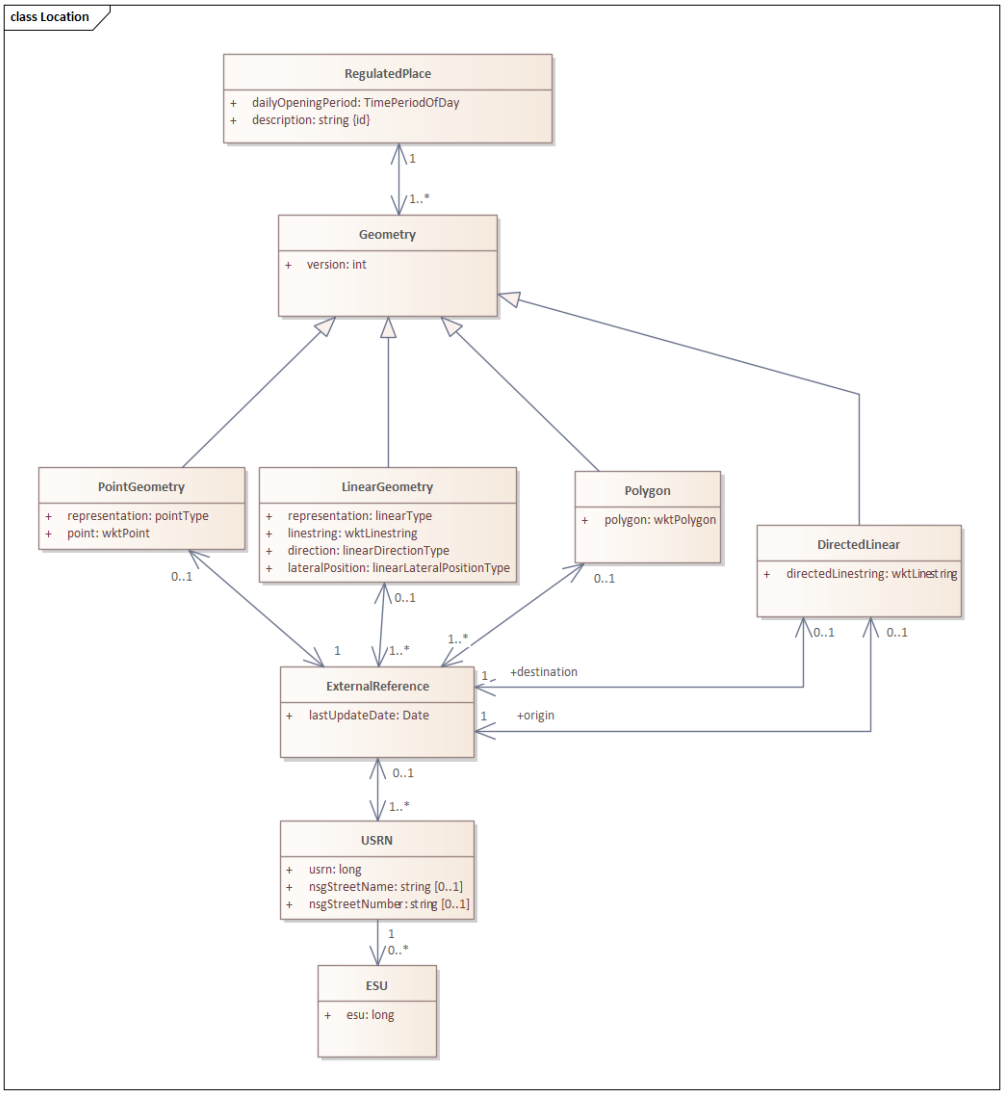



*Figure 13 - Proposed revised D-TRO Data Model structures for Location Referencing*

Figure 14 shows the enumeration values appearing in the location model.

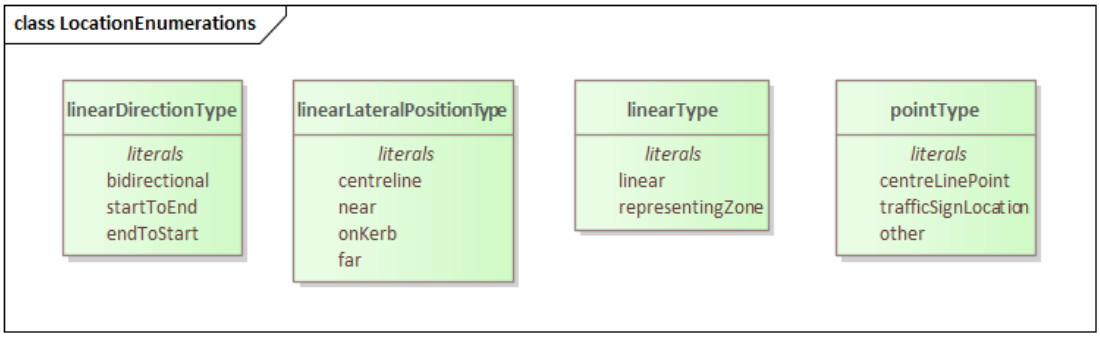



*Figure 14 – Location enumerations*

Expected use of these data structures are as follows.

Each Regulated_Place instance is associated with one or many Geometry class instances. This enables the TRA to segment spatial geometries for a Regulated_Place however they wish.

The Geometry class has an attribute “version”. This attribute enables the TRA to create different versions of representative geometry for a single Regulated_Place. For example, they may wish to

define one version using representation by polylines and another using polygons. Each Geometry class contributing to a version of a Regulated_Place representation shall have the same version number. The first version number, by default, is 0 (zero).

Geometry has four specialisations (a choice of PointGeometry, LinearGeometry, Polygon and DirectedLinear). Each instance of Geometry shall have one of these specialisations.

The potential for associating multiple geometries with a Regulated_Place enables a TRA to subdivide the area of the effect of a TRO regulation into, say, multiple polygons – which may be easier operationally and from a data entry perspective. It is expected that polygons that share no common spatial position shall be defined as distinct Regulated_Place(s). Alternatively, where it is appropriate to define a polygon-based location for a regulation, subdividing this into multiple polygons which share common spatial positions (e.g. shared edge coordinates).

The Polygon specialisation permits definition of one polygon.

Similarly, the LinearGeometry specialisation permits definition of one polyline (linestring).

When specifying regulations for turning movements or directional regulations, the DirectedLinear specialisation shall be used.

The use of the PointGeometry class is preferred for point / gate locations.

There is no technical constraint barring the possibility of creating a series of Geometry classes for one version of a Regulated_Place using a mixture of the four specialisations – however this practice is generally discouraged.

All specialisation instances shall be linked to an external reference providing details from the relevant parts of the National Street Gazetteer.

Each PointGeometry instance or LinearGeometry instance or Polygon instance shall be linked to at least one instance of ExternalReference, containing at least one USRN (or TTRN), and optionally ESUs.

For Polygon locations and LinearGeometry locations external references shall cross reference to all Unique Street Reference Number (USRN), fully or partially, included within the polygon boundary, or the extent of the Linear location, where such USRNs exist.

For turning movements or directional regulations, external references to Unique Street Reference Number (USRN) and Elementary Street Units (ESU), relating to the origin and destination locations shall be specified, where they exist in the NSG.

In all instances where a USRN is provided, either the NSG street name and/or the NSG street number shall be provided.

The coding of wktPolygon and wktLineString shall follow the WKT geometry standard - ISO/IEC 13249-3:2016. An example is illustrated in Table 2.

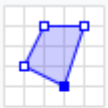
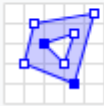
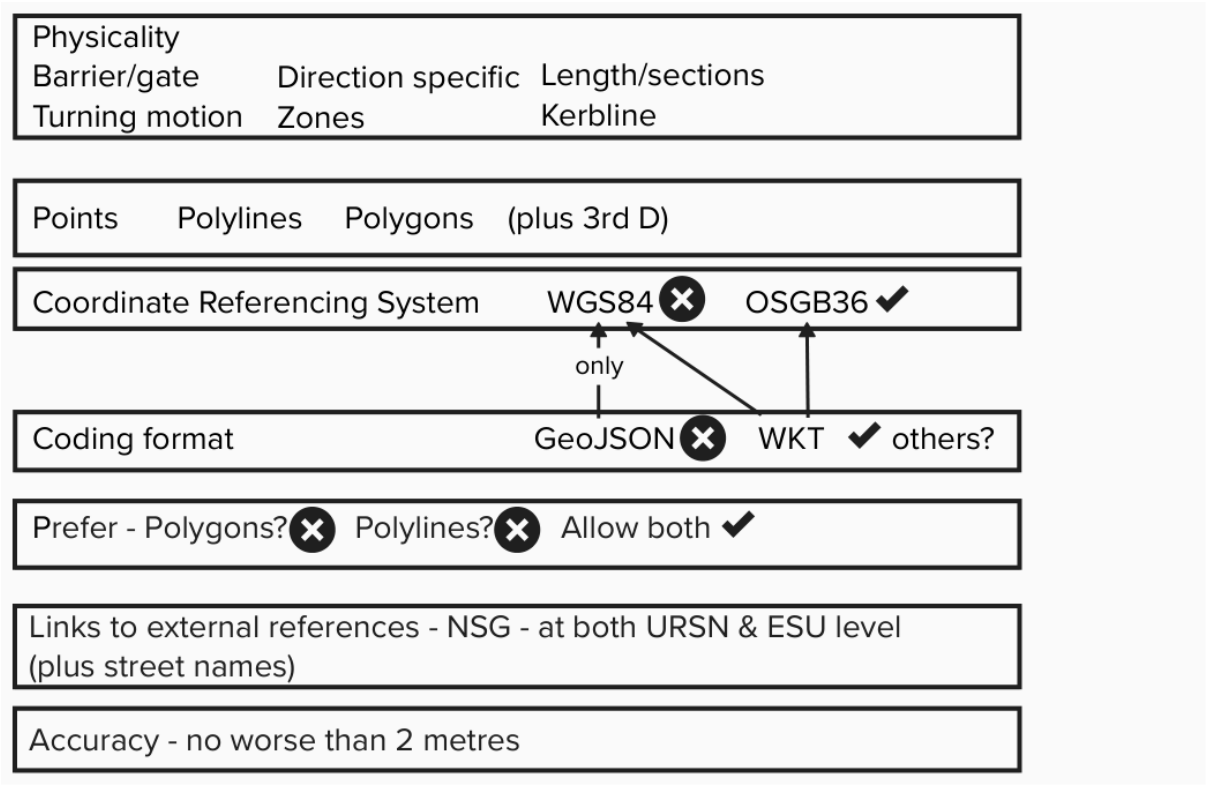
| | | |
|---|---|---|
| Polygon |  | POLYGON ((30 10, 40 40, 20 40, 10 20, 30 10)) |
| |  | POLYGON ((35 10, 45 45, 15 40, 10 20, 35 10), (20 30, 35 35, 30 20, 20 30)) |

*Table 2 - Examples of WKT encoding*

# 9 Pictorial Summary




**Version 2, Dated 3 June 2024**

Drafted by Jonathan Harrod Booth, Harrod Booth Consulting Ltd

Under contract to the Department for Transport