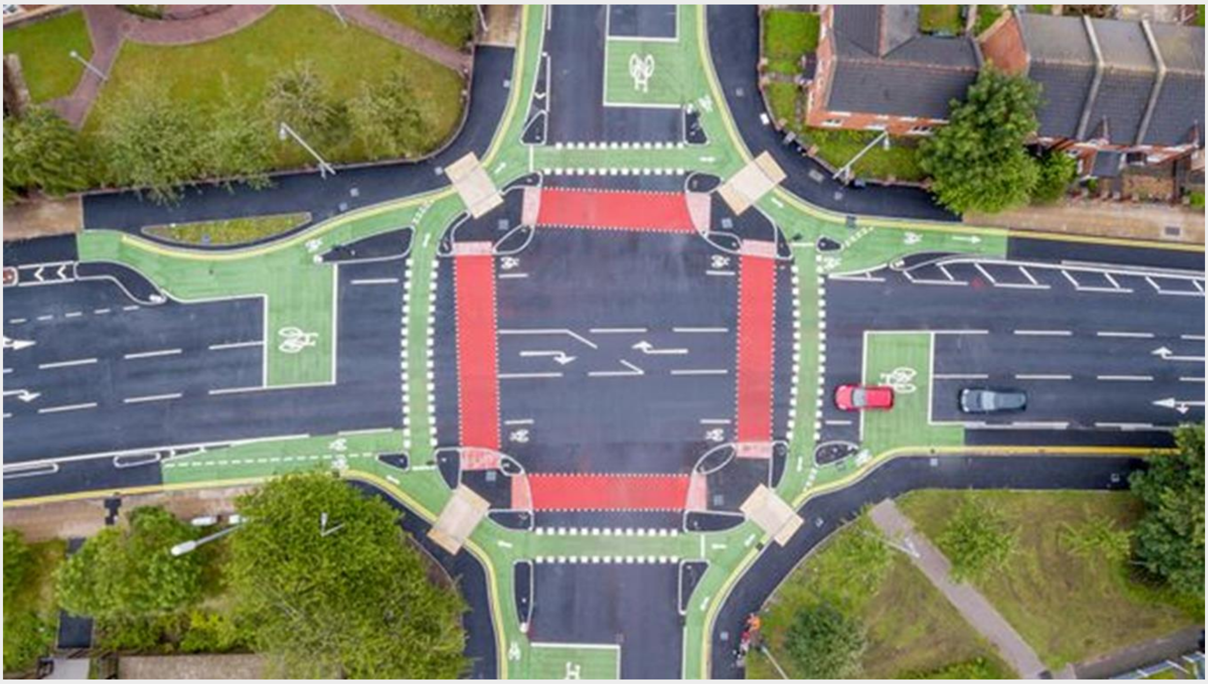
CYCLOPS Junction Design Concept Realisation



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1.0 Abstract

In 2018, TfGM introduced the concept of CYCLOPS (CYCLe Optimised Protected Signals) at the JCT Symposium. CYCLOPS is a traffic signal junction design technique that protects cyclists by providing an external orbital cycle route, separating cyclists from pedestrians and general traffic in space or time. Since 2018 the concept has been brought to life with numerous CYCLOPS junctions either built or in development in Greater Manchester and further afield.

In 2022, this paper 'CYCLOPS Junction Design – Concept Realisation' explores the design methodology in more detail with the aim of helping Traffic Signal and Highway Design Engineers to design, check and approve CYCLOPS junction proposals.

Using real life examples, key design parameters, techniques and modelling are discussed that will enable the production of a junction design with new and improved segregated cycling and walking facilities in line with current best practice (as described in LTN 1/20 for example), whilst ensuring junction capacity and performance are optimised.

2.0 Introduction

CYCLOPS emerged in response to the challenge of providing safer junctions for cyclists that both enable multi-modal user conflicts to be managed safely and maintain overall junction performance.

The design philosophy of allowing cyclists to circulate outside of the controlled pedestrian phases may be considered counter-intuitive as it differs from a conventional highway cross-section where cyclists are positioned between the vehicular traffic and pedestrians. However, this innovative feature establishes an adaptive design template that can be replicated at many different traffic signal junctions from simple cross-roads to complex intersections.

The benefits of an external orbital cycle track include:

- Enables a larger orbit radius providing more storage space for cyclists at signals. The longer turning radii also allows for a more comfortable ride
- Positioning pedestrians on the inside of cyclists can allow crossings to be shorter or even diagonal and hence more direct and closer to desire lines
- Multiple origins/destinations for cyclists can be accommodate as cyclists can filter left on and off the orbital route safely, without the need for signal control
- It is an adaptable template and can be applied in various locations even at junctions with complex internal arrangements

More in-depth information on the CYCLOPS design creation and philosophy can be found in the 2019 publication 'CYCLOPS - Creating Protected Junctions', or contact TfGM Highways UTC for CYCLOPS related queries (*Highways-UTCDesign@tfgm.com*).

3.0 Initiating the Design Process

In order to achieve the optimum layout the design process starts with an analysis of the operation of the existing junction by interrogating a classified turning count of the traffic flows and creating a model (Linsig or equivalent) of the existing layout.

The aim of this analysis is to identify potential deficiencies in the current layout and signal operation in order to work out the most efficient way for the existing traffic movements to transit the junction.

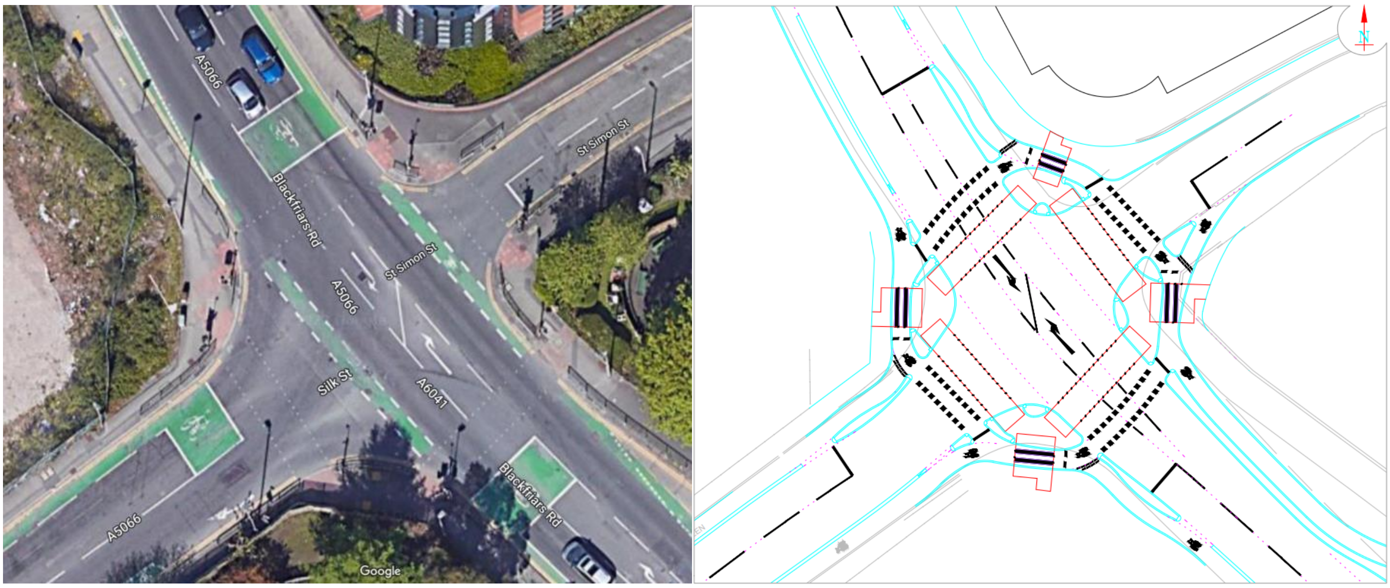
Ultimately, the junction modelling/design iteration process is focused on identifying potential areas of available space that can be liberated for walking and cycling without significantly impacting overall junction operation.

It is worth assessing the entire junction footprint up to the highway boundary with a view to maximising walking and cycling areas. Carriageway space should be strictly limited to cater only for the swept path requirements of the permissible vehicular traffic movements; this is a key design philosophy that will ensure that the length of potentially capacity limiting pedestrian crossing phases are minimised.

Of particular focus in this analysis are:

- Reclaiming underutilised traffic lanes
- Whether right turn movements can be accommodated via right-turn pockets within the junction itself rather than with additional right turn lanes on the approach to the stop line
- Reducing the length of controlled pedestrian crossings by removing islands and utilising the additional space outside the carriageway extents
- Building out the kerblines to at least to the extent of any on-street cycle lanes and transferring the cyclists to an external orbital cycle track creating naturally shorter pedestrian crossings

Figure 1: Spatial Optimisation



Google (2022) Silk Street. Available at: https://www.google.com/maps (Accessed: 19 Aug 2022).

Figure 1 shows an example of an existing junction and the proposed CYCLOPS. The kerblines have been built out encompassing existing cycle lanes. The modelling indicated that right turn pockets would be sufficient to accommodate the existing flows and shorter controlled pedestrian crossings are more efficient.

4.0 2D Geometric Design

Having identified the most efficient staging and lane allocation arrangement based upon the turning count, the focus turns to geometric design and swept-path analysis.

Carriageway Design

Segregated cycling and walking junctions can be relatively 'space hungry', as each mode of transport is given its own dedicated space, often within an existing footprint. Meticulous interrogation of the topographical survey in order to identify space, sometimes over numerous design iterations, will be required to release the sites full potential.

Establishing the criteria to which the junction layout will be designed is important as selecting a more onerous set of standards than may be necessary may limit the ability to maximise the all-important cycling and walking space. For instance, Manual for Streets may be more appropriate for a walking and cycling scheme in an urban or suburban area than DMRB. The tables detailing the recommended minimum horizontal curve radii and lane widths contained within DMRB could make achieving an LTN 1/20 design more problematic within a constrained footprint.

Using variable lane widths that accurately match the design vehicle swept path will help to ensure the carriageway space is limited. Lane widths will increase with curvature (normally with a minimum width specified which may be 3.25m say for the primary lane on a straight section).

A minimum offset would apply (typically 0.5m) from the chosen design vehicle swept-path for all movements and used to ensure adequate clearance between large vehicles and the adjacent kerb-lines.

The swept-path analysis should be carried out in a way which aims to maximise urban realm, footway and cycle-track areas subject to the classification of the road and the proportion and type of heavy goods/public service vehicles making any given movement. For example, roads leading into residential areas could be tracked with tighter turning movements and/or a lower clearance. This is particularly important in creating/maximising the space for the pedestrian corner islands.

The use of compound curve radii has the multiple benefits of slowing traffic, liberating valuable footway space, creating shorter pedestrian crossing distances and ensuring that the poles that house the right-hand push button unit for visually impaired users can be located correctly (i.e. without being too far behind the waiting pedestrian due to the crossing being positioned on a relatively long 8m+ curve radius).

Corner curve radii in design standards often suggest the use of only one arc radius sometimes incorporating a straight taper to assist large vehicle movements as shown in Figure 2 below (from the document: CD 123 Geometric design of at-grade priority and signal-controlled junctions – Figure 5.6.2N2). This can result in under-utilisation of the available space when compared to using more than one curve to match the vehicle tracking swept path.

Figure 2: Traditional Corner Curve Design

Figure 5.6.2N2 Corner radius tapers at priority junctions without diverge tapers or auxiliary lanes

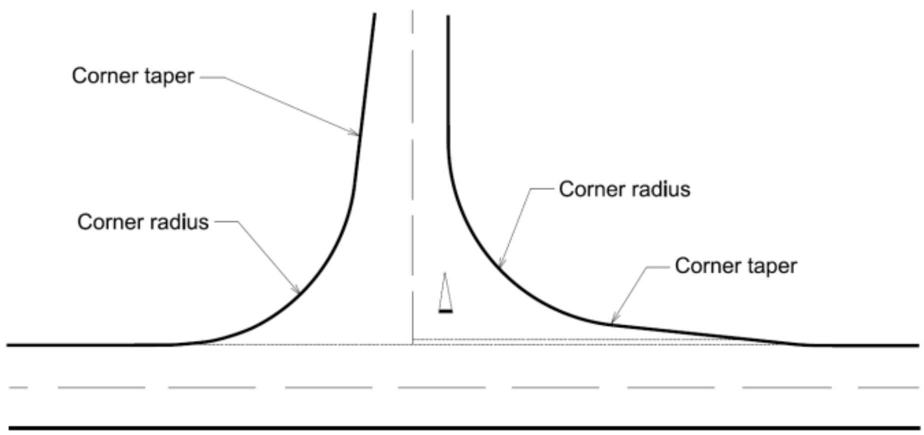


Figure 3: Swept-Path Analysis

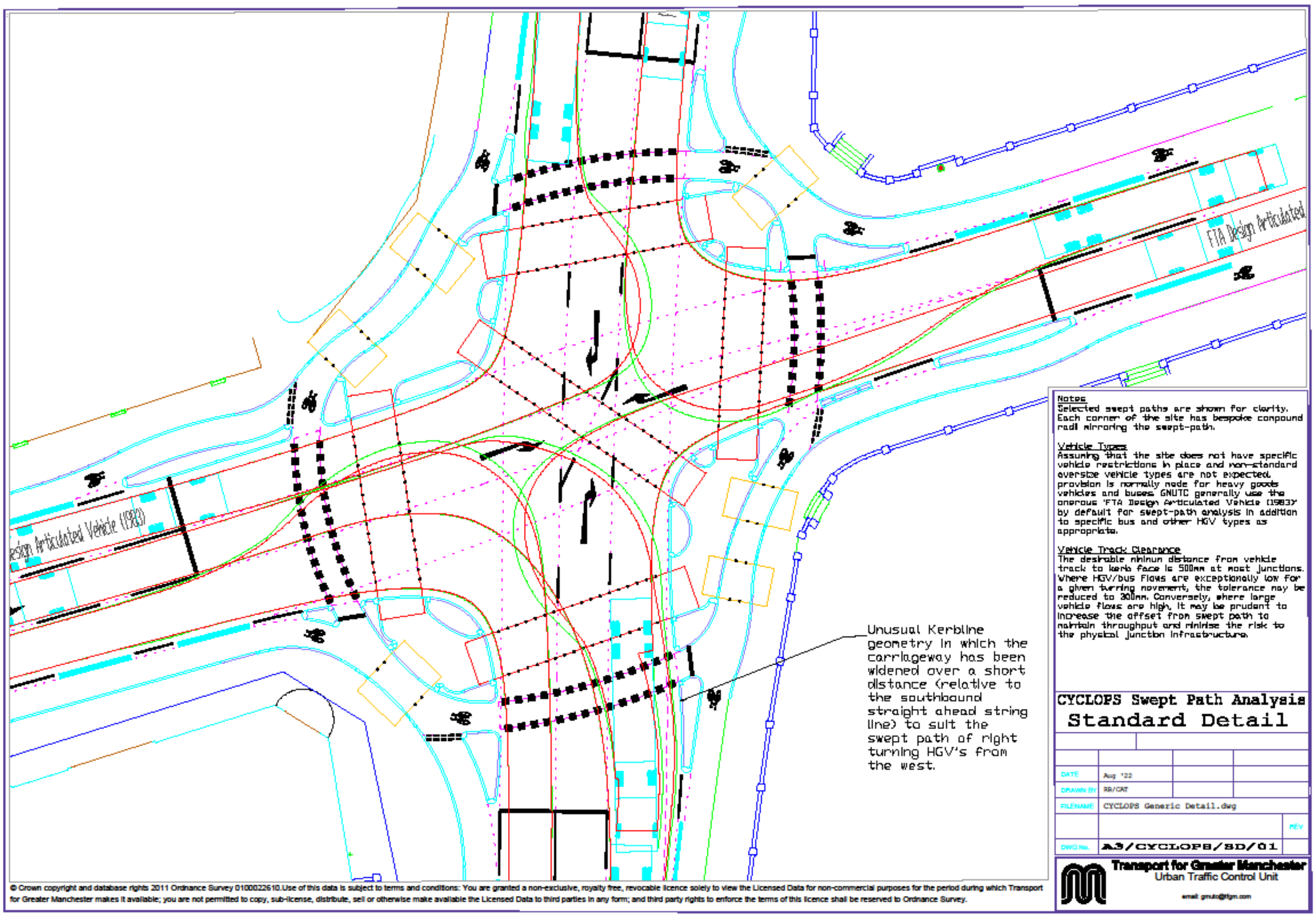


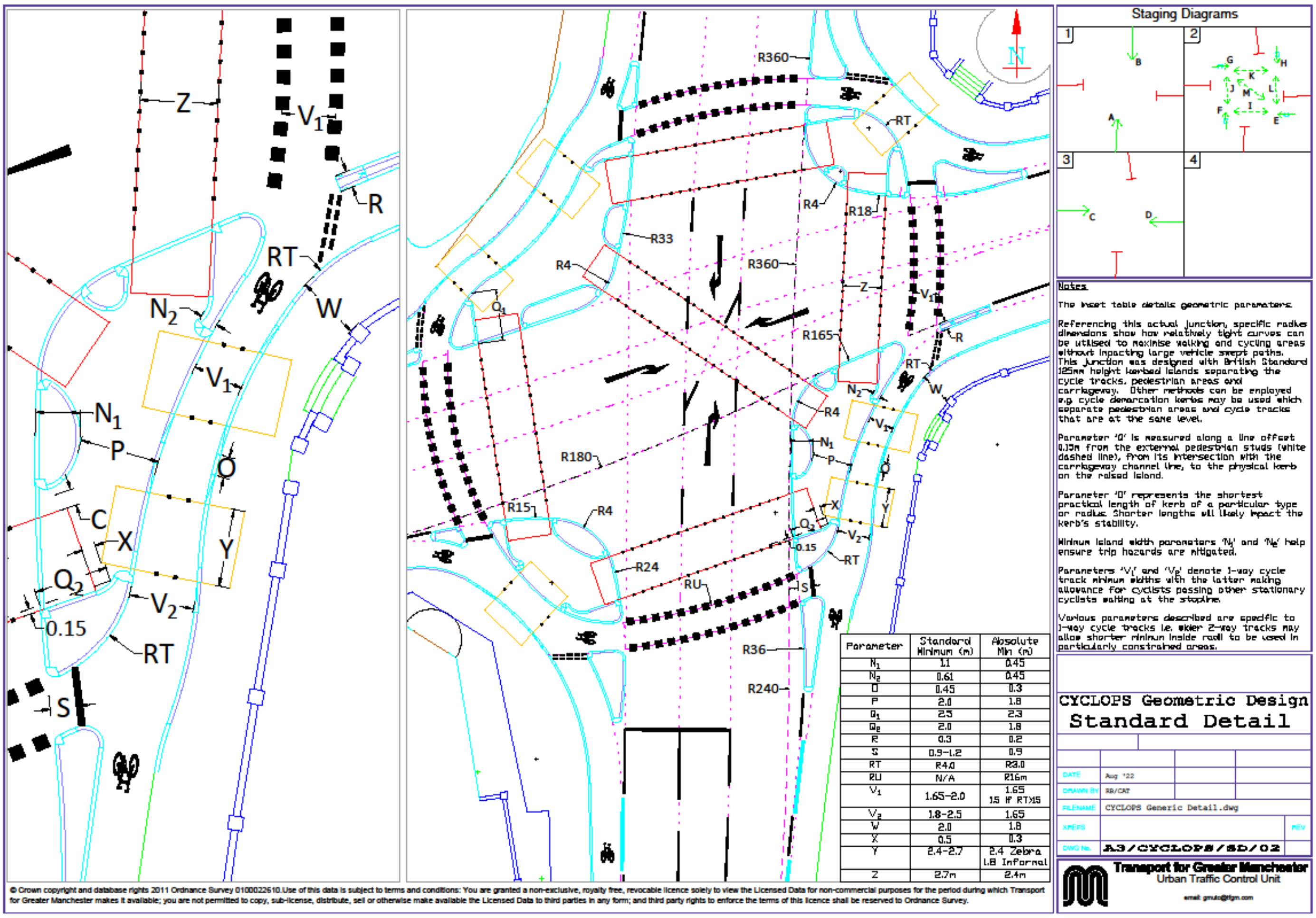
Figure 3 shows examples of compound curve geometry which help maximise the space available for pedestrians and cyclists at a particularly constrained junction.

Careful attention should be given to the creation of the swept path when attempting to achieve the desired space required on a particular corner of the junction. There are a limitless number of paths a vehicle can take to make any given movement.

Cycle Track and Footway Design

Design standards are required to produce functional urban realm drawings which include for cycle track and footway geometry covering elements such as minimum widths and minimum cycle turning radii.

Figure 4: Geometric Design Detail



Parameter	Standard Minimum (m)	Absolute Min (m)
N_1	1.1	0.45
N_2	0.61	0.45
O	0.45	0.3
P	2.0	1.8
Q_1	2.5	2.3
Q_2	2.0	1.8
R	0.3	0.2
S	0.9–1.2	0.9
RT	R4.0	R3.0
RU	N/A	R16m
V_1	1.65–2.0	1.65 1.5 IF RT>15
V_2	1.8–2.5	1.65
W	2.0	1.8
X	0.5	0.3
Y	2.4–2.7	2.4 Zebra 1.8 Informal
Z	2.7m	2.4m

Figure 4 shows annotated geometric design standard drawings currently used by TfGM UTC.

It is useful to have knowledge of the type of kerb type proposed to be used in the construction of the junction. For example, conservation kerbs are available in considerably less radius options than British Standard pre-cast concrete kerbs.

Following consultation with visually impaired user groups, the practice of 'boxing in' pedestrian areas on islands has been introduced to assist with navigation around the junction. Rather than use 'dropper' kerbs to transition from a full height kerb face to carriageway level at a pedestrian crossing, the pedestrian areas are designed to be approximately level with, and on the same plane as the carriageway. Protective islands using full height kerbs encompass the pedestrian areas except where they interface with the carriageway or a cycle track (i.e. at a pedestrian crossing location). Traffic signal poles may either be housed within the protective islands or in the lower pedestrian areas subject to spatial constraints.

Pedestrian crossings of the cycle track may be either of the uncontrolled or mini-zebra type and should be visually distinct and separate from signal controlled crossings of the carriageway. When deciding upon the type of cycle track crossing to be used, consideration should be given to ensuring cyclists have enough room to stop safely in advance of a mini-zebra, especially when exiting the carriageway.

5.0 Traffic Signal Design

Building an understanding of the proposed traffic signal operation and characteristics of the associated equipment is a fundamental part of the design process.

Figure 5: Traffic Signal Design Detail

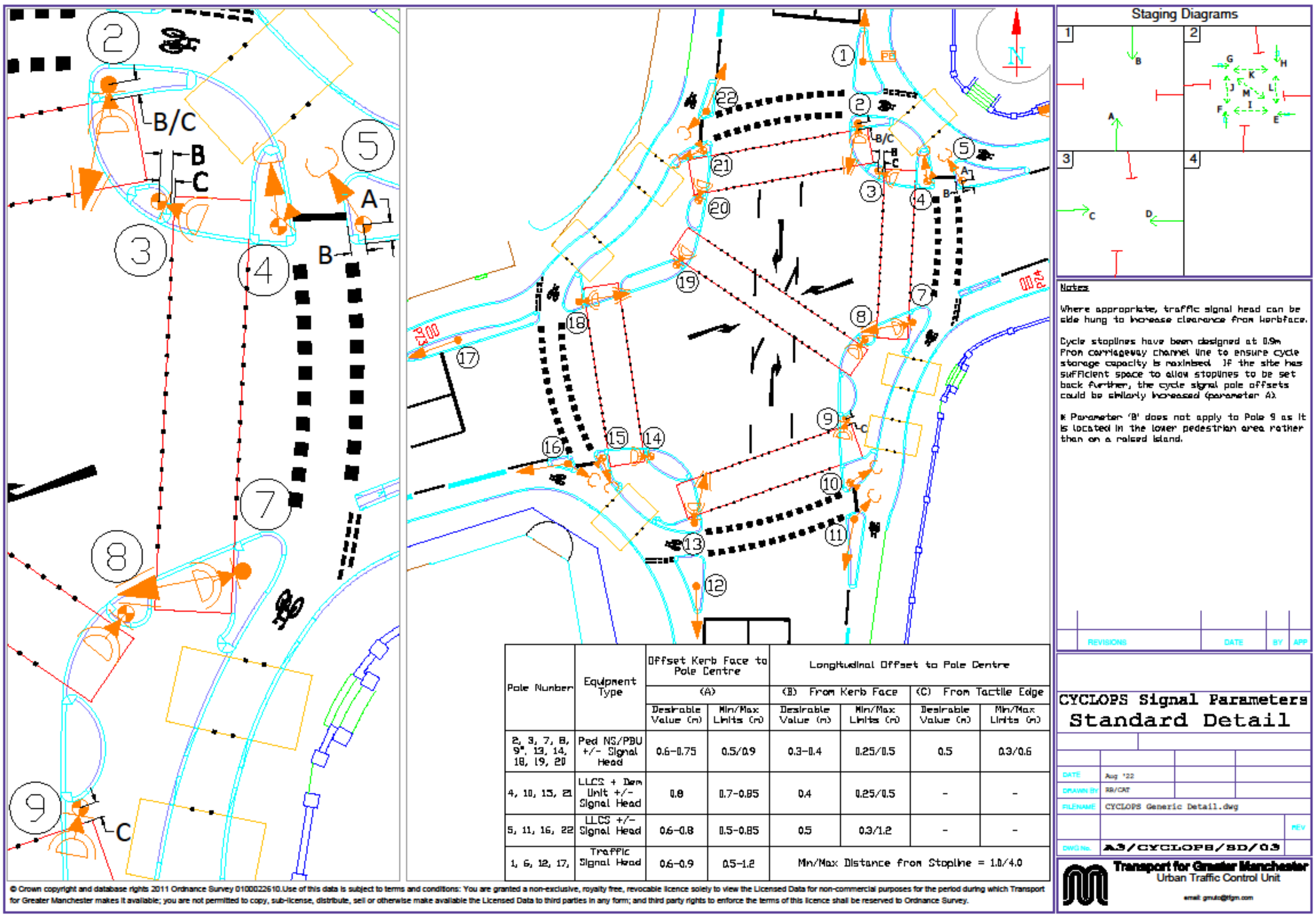


Figure 5 illustrates some of the key traffic signal equipment design parameters that are utilised in the production of a traffic signal design that complements the 2D geometric arrangement.

Additional traffic signal elements that have been important in the development of CYCLOPS are:

- **Cycle Phases** – as with any traffic phase two signal may be considered beneficial to ensure adequate conspicuity and resilience in the event of lamp failure. TfGM UTC's preferred arrangement is to position low level cycle signals to the nearside and offside of the cycle track creating a 'cycle gateway' for each phase.
- **Cycle Phase Delays** – as cyclists travel at a higher speed than pedestrians these can be used to extend cycle phases beyond the end of the combined pedestrian/cycle stage to enable cycle right-turns through two phases to be completed in one stage.
- **Cycle Detection** – in the form of subsurface loops, Piezo strips or overhead detection can be used to place advanced demands for cycle phases. In the event that advanced detection is present, it may be considered that in order to minimise street furniture/clutter an additional dedicated pole with PBU may be omitted in favour of a PBU mounted on the most appropriate cycle signal pole. Rather than being the only mechanism to demand the cycle phase the PBU in this situation is provided positive feedback that the advanced demand has been registered via the Wait Indicator. The push button is thus only required as fallback in the event of loop failure.
- **Revert to Pedestrian/Cycle stage** – at a traditional junction where cyclists share the same phases as general traffic, cyclist will be disadvantaged if the junction reverts to an 'all red' or full pedestrian stage and vehicle

detections needs to be located and tuned carefully. With the pedestrian and cycle phases sharing the same stage the CYCLOPS arrangement is an ideal candidate for reversion to ‘all red’.

- **NFOV nearside indicators** – careful consideration needs to be given to the visibility of any nearside indicator from the mini-zebra or uncontrolled crossing of the cycle track. This is particularly relevant to for a controlled pedestrian crossing located to the right of any mini-zebra crossing.

6.0 Real Life Examples

The following drawings show how the design methodology described above has been put into practice.

Figure 6: CYCLOPS T-junction at a spatially challenging location

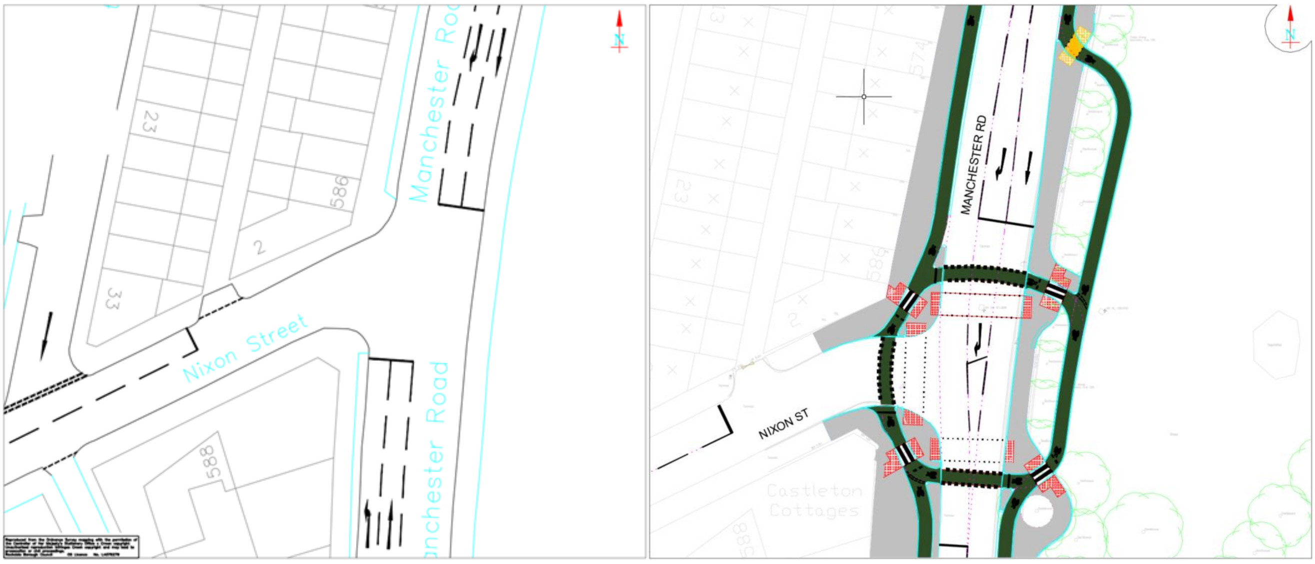


Figure 6 shows how valuable space has been liberated by analysing the existing lane usage which concluded that whilst the right turn lane to the north was important from a traffic perspective, the underutilised left turn lane on the south of the junction could be omitted. The Local Authority owned grassed area to the east has been repurposed to provide an enhanced experience for southbound cyclists and improved urban realm.

Figure 7: CYCLOPS Incorporating a 2-way Cycle Track on One Arm

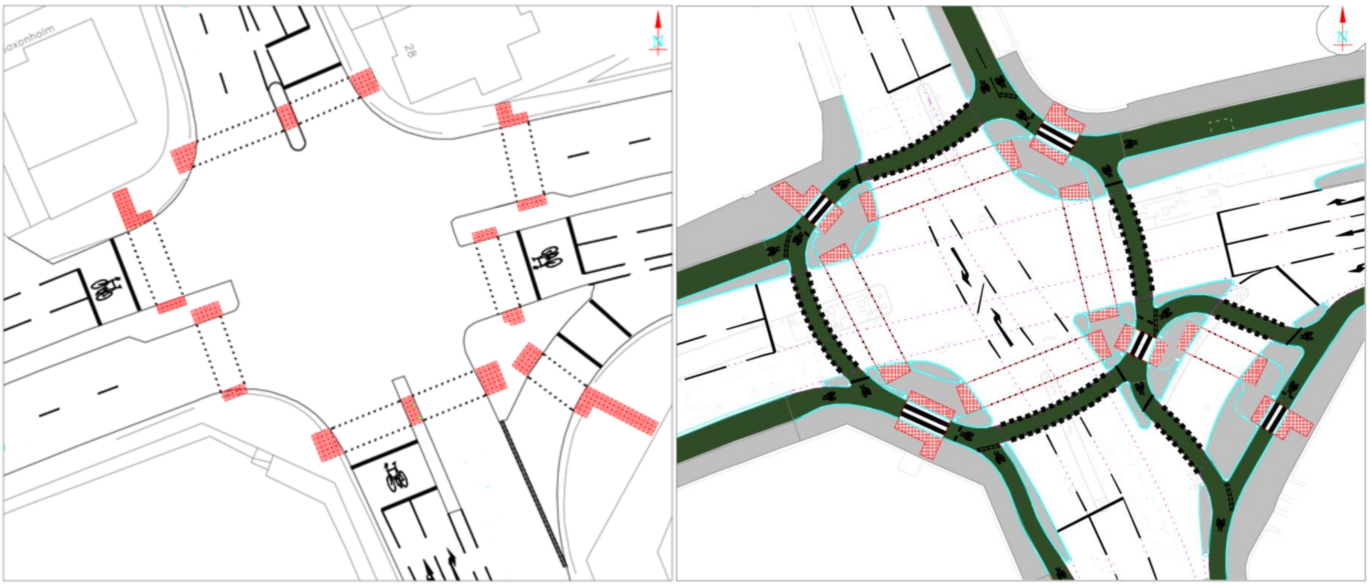


Figure 7 shows another particularly challenging junction from a spatial-fit perspective. The existing junction geometry with its staggered islands and multiphase pedestrian crossings has been rationalised with a more efficient use of space. The CYCLOPS orbital cycle track seamlessly interfaces with a 2-way cycle segregated cycle route on the northern arm.