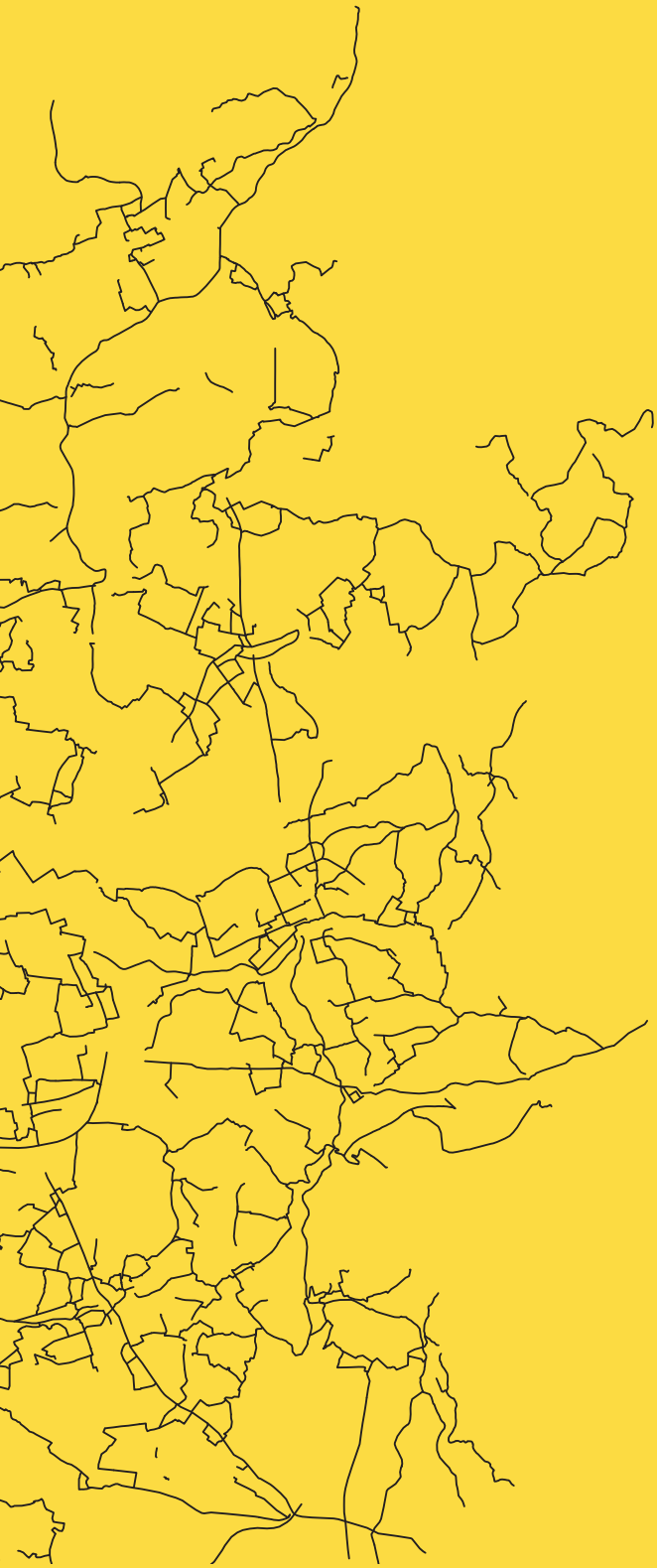


Greater Manchester's cycling and walking network

CYCLOPS – Creating Protected Junctions

Richard Butler, Jonathan Salter,
Dave Stevens, Brian Deegan

July 2019

ANDY BURNHAM
MAYOR OF
GREATER
MANCHESTER

GMCA GREATER MANCHESTER COMBINED AUTHORITY

Transport for Greater Manchester

Abstract

This paper introduces the concept of CYCLOPS, an innovative design philosophy for the creation of protected traffic signal junctions. The principle feature is an **external orbital cycle track** separating cyclists from vehicular traffic in time or space, thus enabling multi-modal user conflicts to be managed safely. CYCLOPS designs were first presented at the JCT Traffic Signal Symposium in September 2018.

To meet the challenge of providing safer junctions for cyclists whilst maintaining overall junction performance, the CYCLOPS design technique emerges as an adaptable template which allows all types of junction arrangements to be incorporated within an external orbital cycle track, from a simple cross roads with full pedestrian stage, to a major intersection requiring complex traffic and pedestrian phasing. The inherent adaptability of CYCLOPS enables a comprehensive and uniform provision of cycling facilities at traffic signal junctions.

In the future, it is expected that the proportion of people walking and cycling will increase. CYCLOPS junctions naturally accommodate this modal shift as traffic signal ‘stages’ that allow both pedestrian and cycle ‘phases’ to run simultaneously become increasingly valuable as more people choose to walk or cycle.

Background

In the UK, cycling has a low modal share and the cycling infrastructure is of a lower quality compared to other Northern European countries.

Whilst cycling is a relatively low risk activity, with health benefits outweighing the risks, many cyclists and non-cyclists do not feel safe on UK roads. Furthermore there is an established pattern of serious and fatal accidents at junctions caused by left turning vehicles, crossing the path of cyclists travelling straight ahead.

From an infrastructure perspective, the existing National Cycle Network tends to utilise:

- Disused railway lines, canal towpaths or quiet roads to avoid busy junctions
- Cycle lanes and Advanced Stop Lines (ASL's)
- Shared use pavements and toucan crossings

The limitations of the existing infrastructure have led to:

- Complaints from cyclists about a lack of safe facilities on principle routes and at junctions in particular
- Complaints from pedestrians, particularly from visually impaired users, about cyclists using the footway

The issue of cycle safety (actual and/or perceived) remains a constant challenge for design engineers.

In Greater Manchester the establishment of a directly elected Mayor and the appointment of Chris Boardman MBE as Greater Manchester's Walking and Cycling Commissioner has led to a multi-million pound investment in active travel, with the aim of tackling issues such as Climate Change, Air Quality, Road Safety, Congestion and Obesity across the City Region.

In response to this challenge, TfGM set out to provide safer junction designs, comparable to European best practice. However, since the UK lacks "give way on turning" and "presumed liability" rules, Dutch or Danish designs do not translate easily into a UK context.

The Need for Protection at Junctions

The primary aim of any type of protection at a junction is to ensure that people who cycle or walk feel safe and **are** safe. At a traditional traffic signal junction in the UK, dedicated red/green man facilities provide protection for pedestrians whilst cyclists typically share the carriageway and associated signal phasing with vehicular traffic. Cyclists are often positioned in the nearside of the lane allowing vehicles to pass on their offside - this gives rise to serious conflict when their destinations are different (e.g. cyclist going ahead and a vehicle turning left from the same lane). Moreover, the addition of a nearside cycle lane actively encourages cyclists to adopt a potentially dangerous position if the adjacent lane contains left turning vehicles.

Existing Forms of Protection in the UK

The growing recognition of the need to improve cycle safety has led to the development of a number of different forms of protection for cyclists at signal junctions. Four established forms of protection were reviewed for potential implementation in Greater Manchester: Early Release; Cycle Gate; Cycle Only Stage, and Hold-the-Left as described below.

1. Early Release

A green cycle aspect operating as a filter runs for a short period preceding the associated vehicular traffic phase for a given approach. Cyclists utilising the Early Release can proceed without vehicular traffic conflict. Cyclists arriving whilst the associated general traffic phase is at green may still proceed but without protection.

Figure 1: Cycle filter in Fallowfield
(helps cyclists clear nearside bus-stop)

Figure 2: Cycle gate in Westminster

2. Cycle Gate

Cyclists and general traffic are separately signalled via a two-stage signal node into a reservoir leading to a signal phase and associated stop-line at the main junction. Conventionally, the cyclists would be signalled into an empty reservoir and then held at a red signal at the main junction. Both the main junction's shared signal phase and the upstream traffic-only signal phase are then brought to green simultaneously allowing for a de facto 'early release' as the cyclists are positioned significantly further forward than the traffic when the greens are displayed. Subtle signal timing changes can help improve separation between cyclists and traffic or overall capacity as desired.

3. Cycle Only Stage (Phase)

Cyclists have a dedicated phase for any given approach. Multiple stages may be required to accommodate all cycle movements to ensure cycle-cycle conflicts are managed (assuming that it is not acceptable to provide a cycle scramble where all cycle phases are shown green simultaneously).

Figure 3: Cycle stage in Radcliffe (linking two quiet streets)

4. Hold-the-Left (with a 2-Stage Right Turn)

Hold-the-left requires separate signal control of the left turn (and opposing right turn) such that the ahead traffic and parallel cycle phases can run together. In other parts of the UK, hold-the-left is often used in conjunction with a 2-stage right turn in which cyclists wishing to turn right position themselves in a designated area within the controlled zone and in advance of the adjacent (left hand side) arm's stop-line. The cyclists can then use the secondary signal of the adjacent arm as an indication of when it is safe to proceed (the 2nd 'stage' of the right turn movement).

Figure 4: Hold-the-left in Camden

Evaluating Protection at Junctions

In addition to the fundamental aim of providing facilities that promote safe cycling and walking, overall junction performance should be optimised such that other modes of transport are not adversely affected. In view of this, the following four criteria were used to evaluate the existing forms of protection described above.

Conflict:
How effectively multi-modal user conflicts are resolved

Capacity:
How effectively vehicular traffic flow is maintained

Delay:
How efficiently pedestrians and cyclists transit the junction (minimising delays at red signals for given routes)

Spatial Efficiency:
How efficiently the mode-specific elements (pedestrian, cycle, traffic facilities etc) are accommodated in to the junction footprint

---

The table below illustrates how each type of cycle protection performs when assessed using the evaluation criteria:

		Forms of Protection for Cyclists at Signal Junctions			
		Early Release	Cycle Gate	Cycle Only Stages	Hold-the-Left with 2-Stage Right-Turn
Evaluation Criteria	Conflict	Poor	Moderate	Good	Moderate *
	Capacity	Poor	Poor	Poor	Good
	Delay	Good	Poor	Poor	Moderate
	Spatial Efficiency	Good	Moderate	Good	Moderate
		*Good for cyclists travelling ahead/left, uncertain for 2-stage right-turners			

Given that each of the existing forms of protection has limitations, it was evident that establishing a template for a junction that performed well by all four criteria would require a radical re-think.

Determining Guiding Principles for Protected Junctions

In order to formulate a new design philosophy, the essential question is:

"What are the fundamental elements that need to be included in an ideal protected junction?"

1. Pedestrian routes and areas should be clear and intuitive (including for the visually impaired) and not compromised in order to accommodate cycle facilities
2. Cyclists should ideally be treated as a separate mode, independent of vehicular traffic
3. Cyclists, pedestrians and vehicular traffic modes should be separated in space or time
4. Identify and manage inter/intra-modal user conflicts: eliminate, minimise, simplify, signalise?
5. Cycle / traffic conflicts will typically require signal control
6. Cycle / pedestrian interaction should be simple and intuitive with points of conflict preferably not managed by signal control
7. Cycle / cycle only conflicts should be simple and intuitive and preferably not managed by signal control
8. Cycle movements should not be subject to unnecessarily tight turning radii
9. Aim to minimise divergence from pedestrian desire lines and shorten crossing distances
10. Aim to minimise cycle movements subject to signal control by eliminating conflict or simplifying interaction with vehicular traffic
11. Aim to allow cyclists to bypass or be exempted from traffic regulation orders prohibiting movements that apply to general traffic
12. Aim to provide sufficient space such that cyclists waiting to make a movement do not block cyclists with an alternative destination
13. Minimise any potential negative impact of new facilities on all junction users and the road network

Roundabouts effectively manage all movements at multiple arm intersections without necessarily requiring signal control. Managing cycle-cycle conflicts via the established give-way-to-the-right principle of a roundabout was determined to be the most logical avenue to pursue as it minimises the additional complication associated with treating cycling as a mode independent of vehicular traffic and pedestrians.

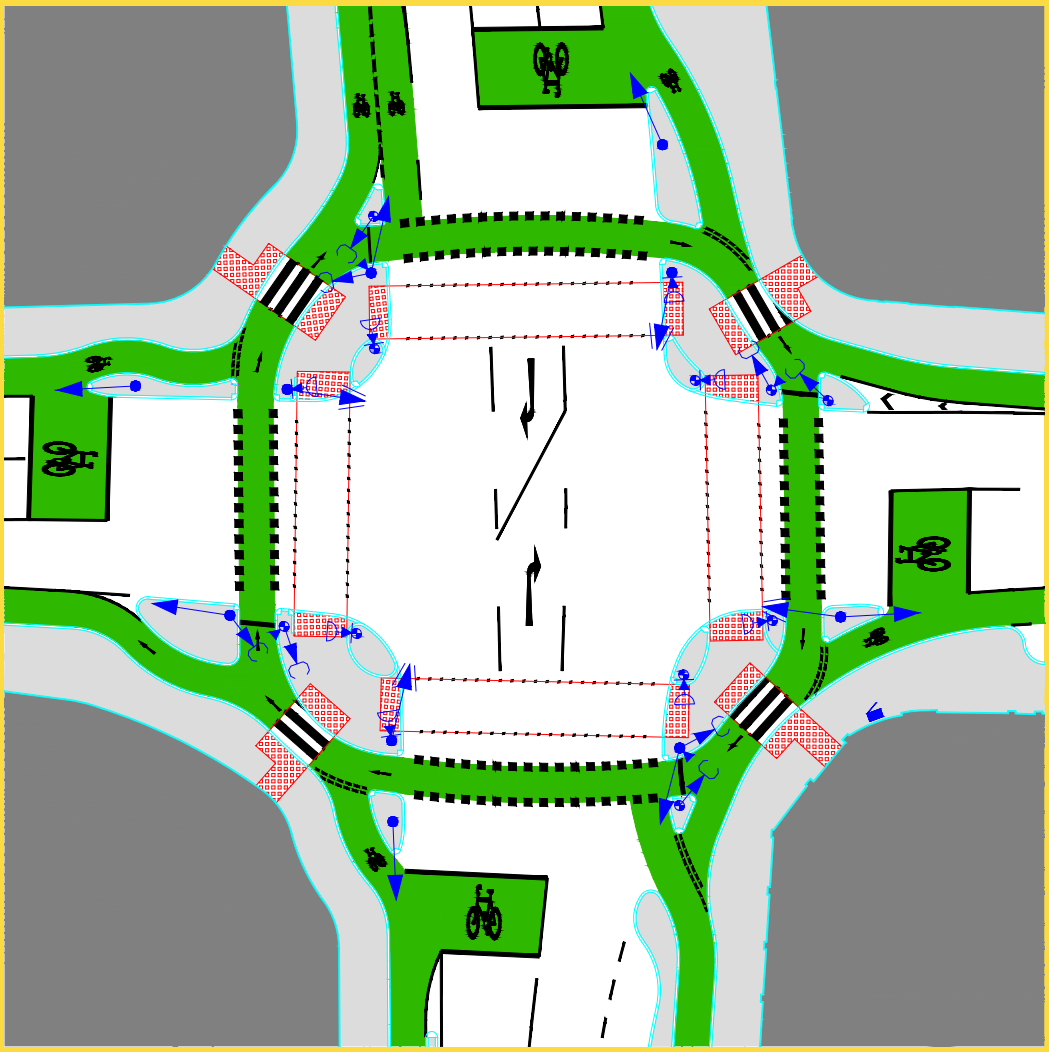
In this respect, it was evident an orbital cycle system that minimises the number of phases/ stages required to accommodate all cycle movements was the ideal scenario.

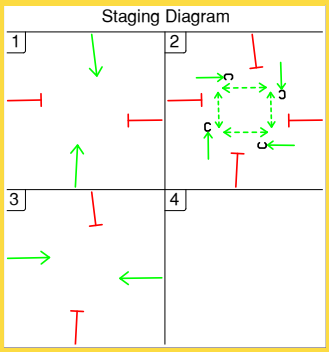
The First CYCLOPS

CYCLOPS is a design technique for the creation of traffic signal controlled junctions that protects cyclists by providing an orbital cycle route separating cyclists from general traffic in space or time.

• **CYCL**e	Key feature being an orbital cycle route
• **O**ptimised	Safety enhancements for all junction users with delays minimised
• **P**rotected	Cycling and walking conflicts with vehicular traffic are safely managed
• **S**ignals	Signal controlled junction design technique

Figure 5: The first CYCLOPS





An illustration of the prototype CYCLOPS design complete with controlled Zebra crossings of the cycle track. The cycle lanes approaching from the four arms converge on the roundabout-style cycle track which completely encircles the junction. The majority of the controlled zone is contained within this ring.

CYCLOPS: The Benefits of an External Orbital Cycle System

In addition to minimising the number of phases/stages required to accommodate all movements, orbital cycle systems have other important benefits:

1. All cycle-traffic conflicts can be signalised
2. Cycle phases can run simultaneously during an 'all red to traffic' stage
3. Cycle / cycle conflicts are simple, intuitive and need not be signalised
4. Cyclists can make fully protected 2-phase-right-turns (subject to signal staging and timings, this may be achieved in one movement or with little delay)
5. Controlled cycle and pedestrian phases need not conflict and can run simultaneously
6. Accommodating multiple origins/destinations is more straightforward

In a conventional highway cross-section, cyclists are positioned between the vehicular traffic and pedestrians. When designing a junction incorporating an orbital cycle track, it would at first appear logical to maintain this spatial relationship such that cyclists are located within the area bounded by the pedestrian crossings of the junction arms – in essence, an **internal** orbital system.

On further investigation, there were actually numerous advantages with an external orbital system. The following benefits are realised (or can be achieved within a smaller junction footprint) when the cycle track is **external** rather than internal:

1. Larger orbit radius ensures
   - more space for storage at cycle signals
   - more comfortable, longer turning radii
2. Cyclists can filter left onto and off the orbital route without signal control
3. Controlled pedestrian phases are shorter and closer to desire lines
4. Potential for diagonal pedestrian crossings
5. Potential for complex signal staging incorporating walk-with-traffic pedestrian phases

Figure 6: Proposed CYCLOPS in Chorlton District Centre

The skewed junction geometry opens up the possibility of a diagonal pedestrian crossing.

In the ideal scenario, space permitting, pedestrians should only need to cross the cycle track if they also need to cross the carriageway (i.e. left turning pedestrians have a continuous footpath and do not interact with cyclists).

CYCLOPS Design Philosophy – an Adaptable Design Template

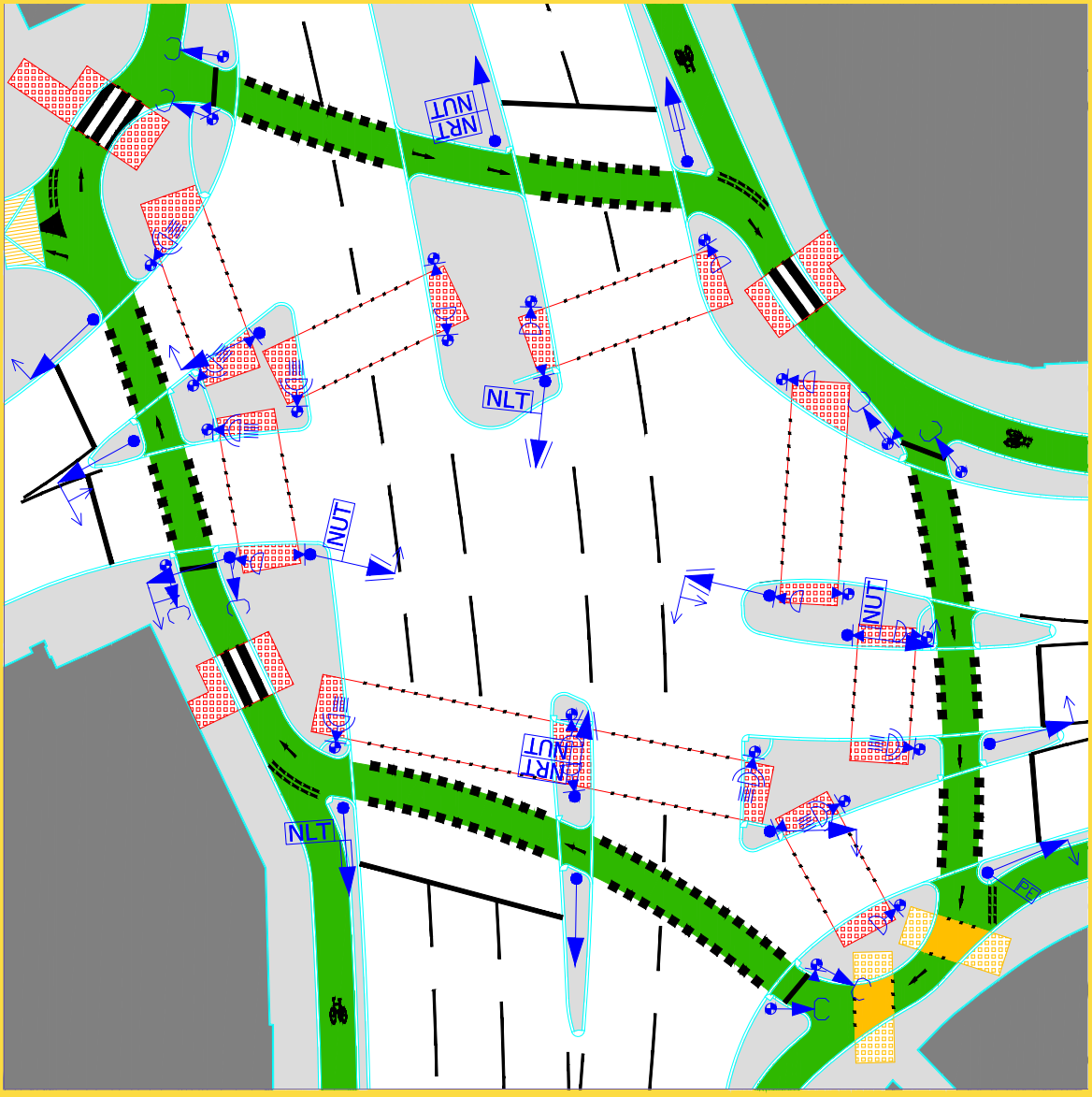
The prototype CYCLOPS envisioned an external orbital system around a simple cross roads with a full pedestrian stage.

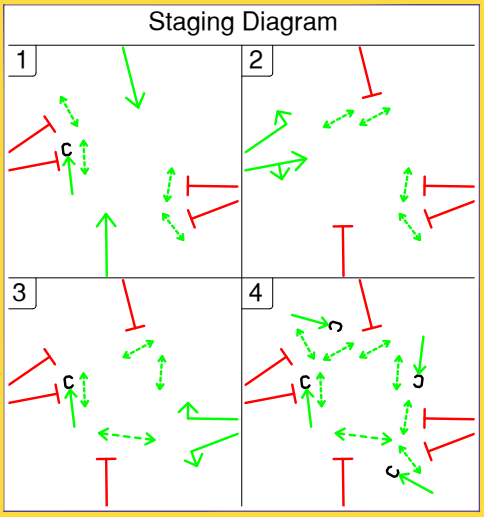
Having established the benefits of CYCLOPS, the next challenge was to explore how the CYCLOPS design philosophy could be applied to more complex junction arrangements giving rise to an adaptable design template for cycling and walking in Greater Manchester.

The following three design proposals show how CYCLOPS allows for complex and efficient traffic and pedestrian phasing and associated island geometry within the external orbital cycle track.

Figure 7a: CYCLOPS with walk-with-traffic pedestrian phases

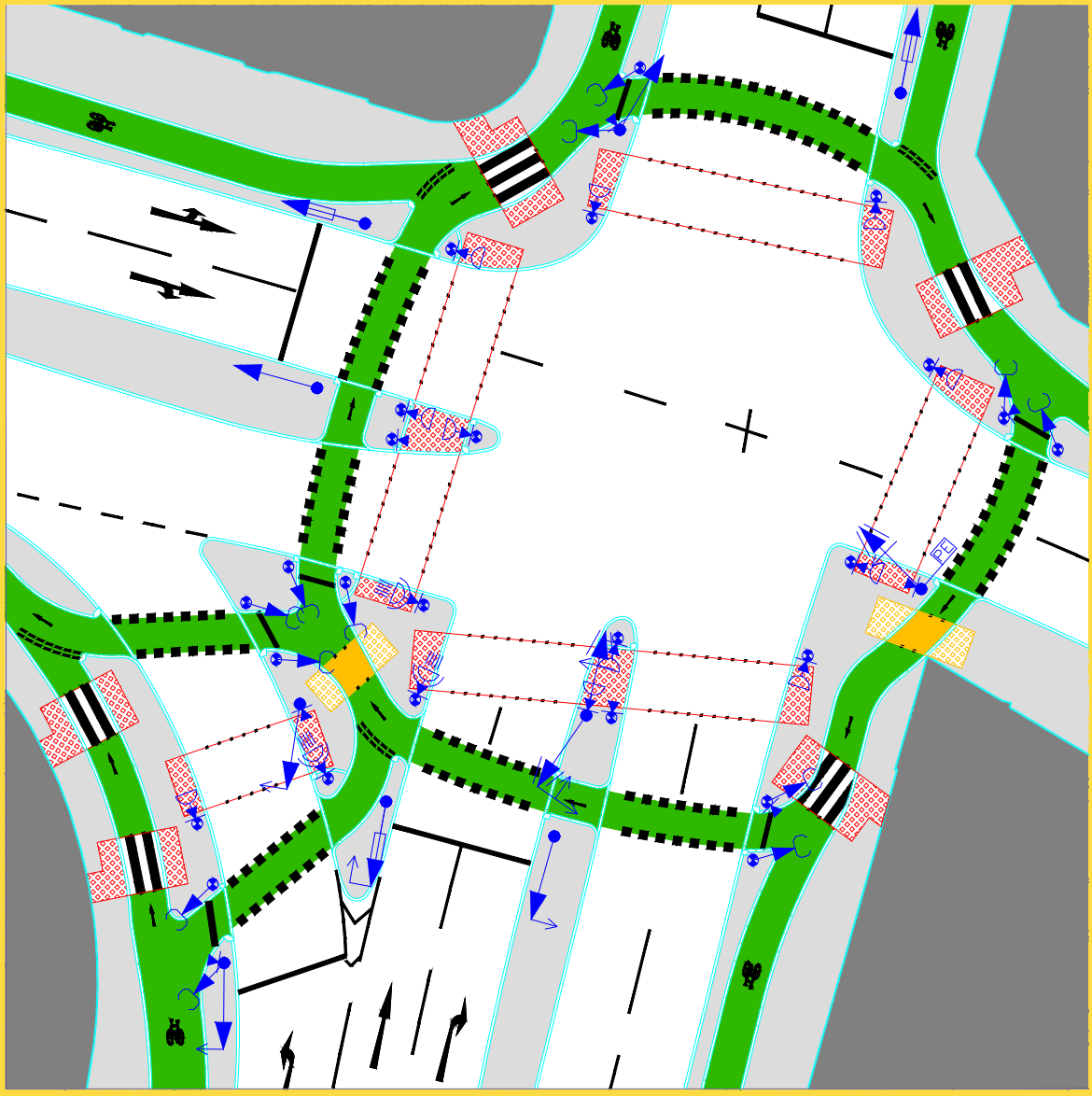
Figure 7b: CYCLOPS with walk-with-traffic pedestrian phases

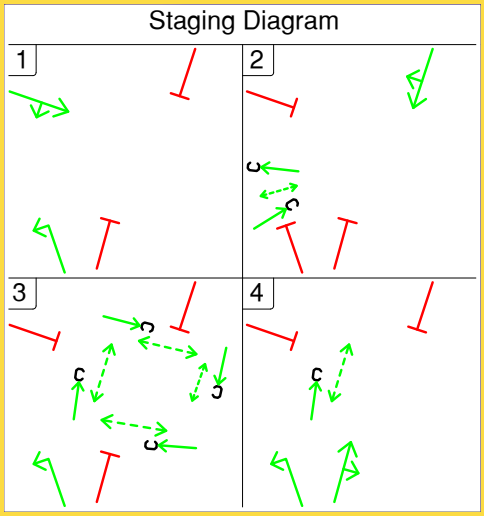




Proposed CYCLOPS design and visualisation in Bolton incorporating walk-with-traffic pedestrian phases to achieve a capacity neutral design. Cycle phases have lower intergreens than pedestrian phases of the same length. This enables straight across cycle phases to be installed in situations where staggered pedestrian crossings are required to maximise junction capacity.

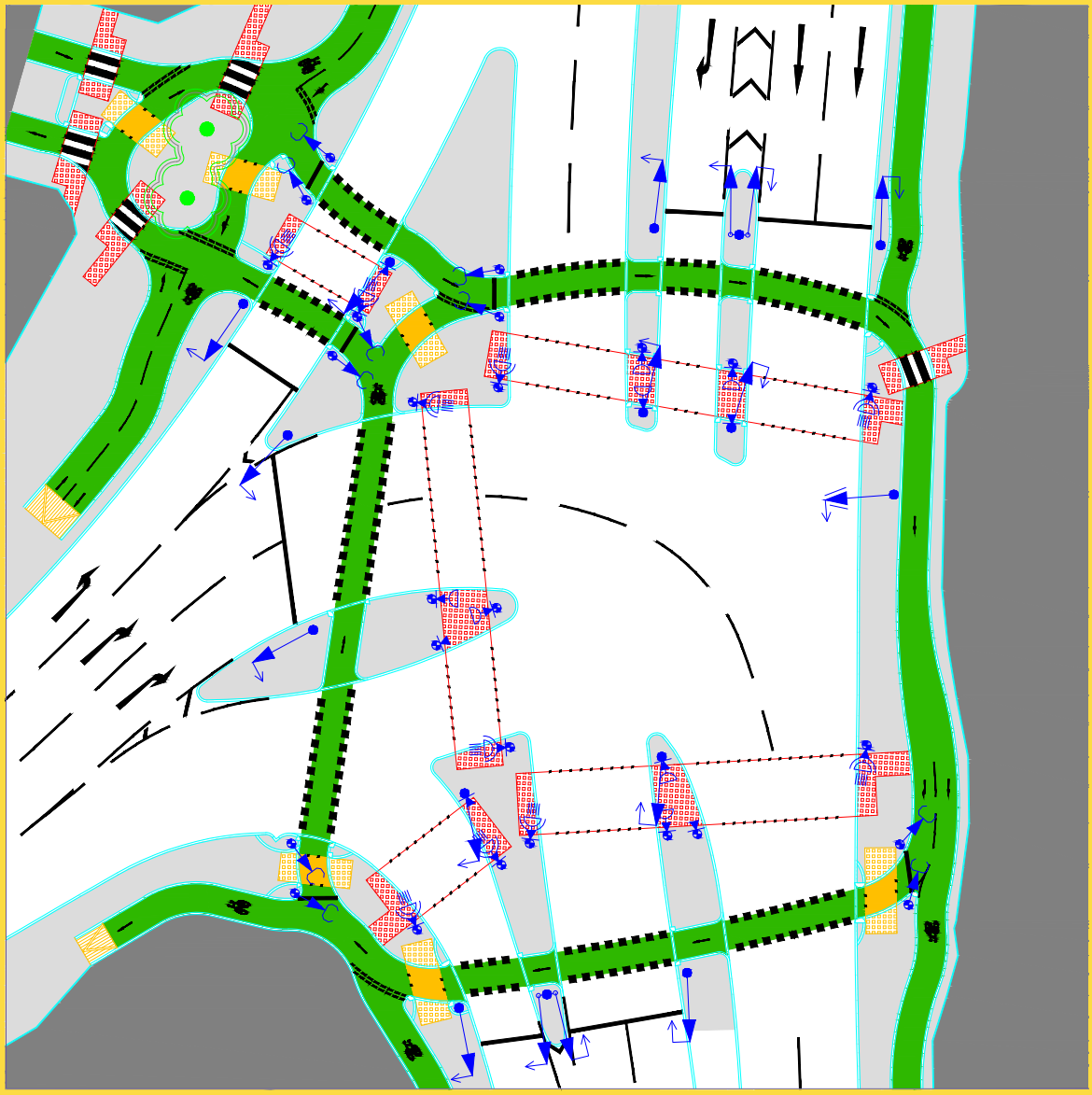
Figure 8: CYCLOPS accommodating large left turn flow

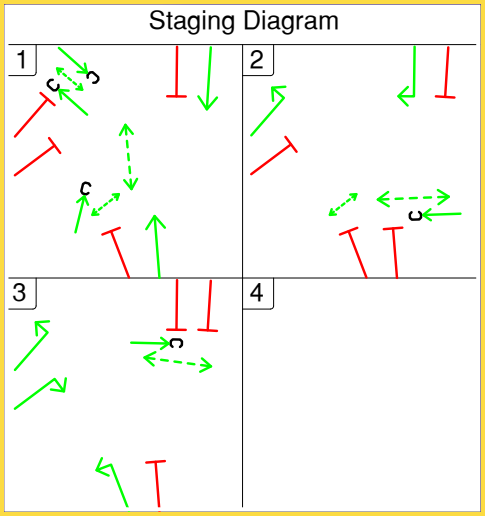




A proposed junction where a triangular island has been appended onto the CYCLOPS enabling the orbital cycle and parallel pedestrian phases to run with the very large left-turn traffic flow thus maintaining junction capacity.

Figure 9: CYCLOPS incorporating hold-the-left

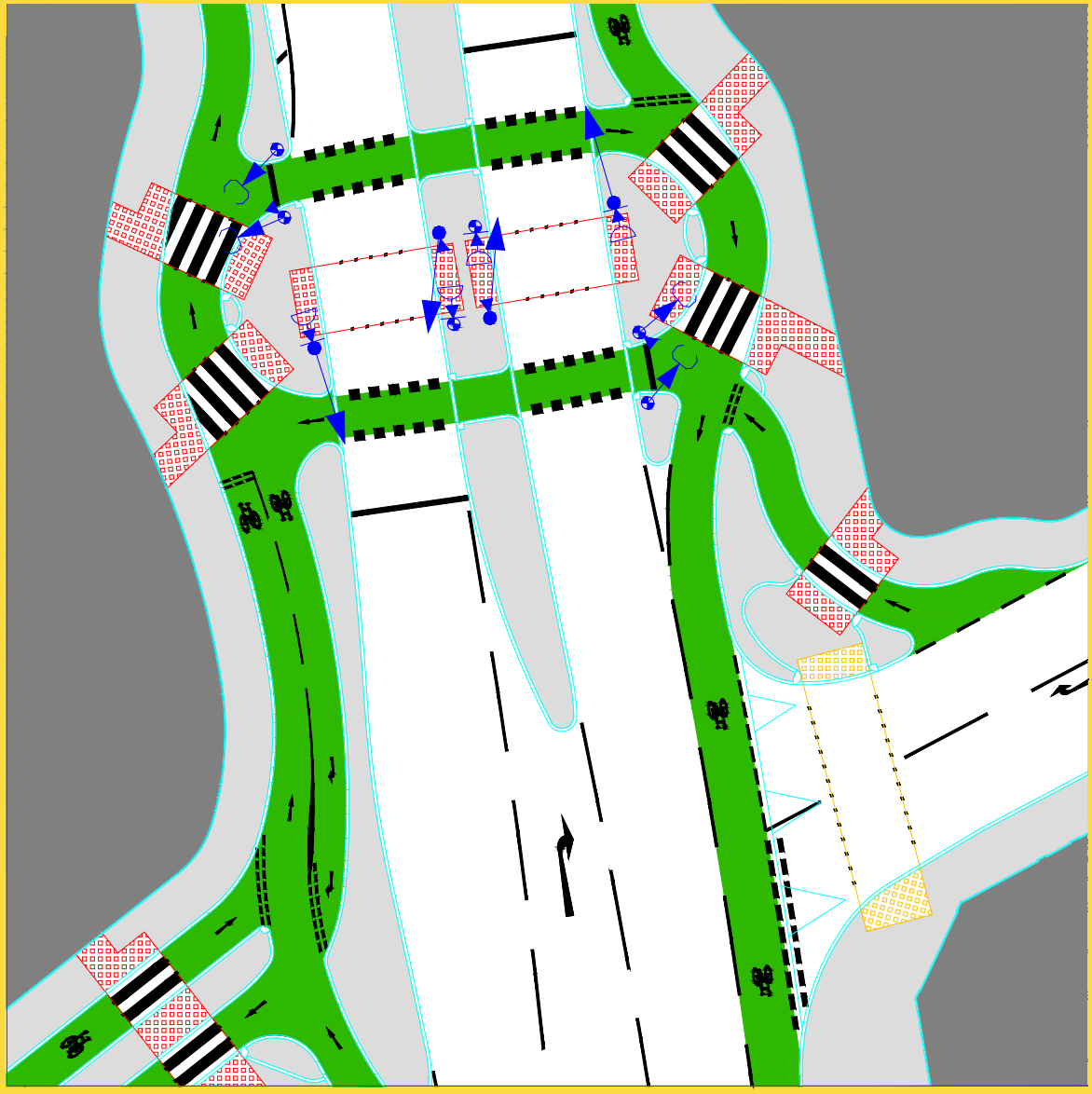




A proposed CYCLOPS which incorporates hold-the-left and separately controlled right turn for general traffic in order to maximise the green time available on the main north-south cycle route (kidney bean cycle roundabout to avoid mature trees is optional!)

CYCLOPS can also be realised in simpler forms

Figure 10: CYCLOPS as a standalone pedestrian / cycle crossing



A proposed CYCLOPS at the intersection of a major arterial north-south cycle route and an important quiet-streets east-west route. It is a simple two stage arrangement with pedestrian and cycle phases running simultaneously.

Comparing CYCLOPS and Existing Forms of Protection for Cyclists

The table below illustrates the benefits of CYCLOPS and how it compares with the existing forms of protection for cyclists:

		Forms of Protection for Cyclists at Signal Junctions				
		Early Release	Cycle Gate	Cycle Only Stages	Hold-the-Left with 2-Stage Right-Turn	CYCLOPS
Evaluation Criteria	Conflict	Poor	Moderate	Good	Moderate *	Good
	Capacity	Poor	Poor	Poor	Good	Good
	Delay	Good	Poor	Poor	Moderate	Good* / Moderate
	Spatial Efficiency	Good	Moderate	Good	Moderate	Good

*CYCLOPS can be categorised as 'Good' for 'Delay' as multiple cycle movements can bypass signal control, and, cycle phases may be able to run in multiple stages running in parallel with traffic phases as well as pedestrian phases. Hold-the-left or similar efficient phasing regimes can be designed within the external circulating cycle track.

Conclusion

The CYCLOPS design concept allows all types of junction arrangements to be incorporated within the external orbital cycle system, from a simple cross roads with full pedestrian stage, to a major intersection requiring complex traffic and pedestrian phasing.

The inherent adaptability of CYCLOPS enables uniformity in the provision of cycling facilities at traffic signal junctions. When encountering a CYCLOPS it will be recognisable and intuitive by virtue of the presence of a 'traditional' junction managing pedestrians and traffic conflicts, contained within an orbital cycle track.

In the future, it is expected that the proportion of people walking and cycling will increase. CYCLOPS junctions can easily accommodate this modal shift as pedestrian and cycle phases running in parallel simultaneously benefit from green time reallocated from traffic stages.

In summary, CYCLOPS maximises the opportunities for safe cycling and walking whilst optimising the overall junction performance for all modes.

Photography and visualisations
TfGM, Planit-IE

19-1369