Chris Kennett Consulting Limited
Traffic Signal Engineering

Squaring the Circle

Designing High Quality Cycling, While Adding Traffic Capacity

JCT Symposium 2023

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Based on work undertaken by Chris Kennett Consulting Limited with Milestone Infrastructure Services, on behalf of Peterborough City Council

MILESTONE INFRASTRUCTURE
A part of MGroupServices

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PETERBOROUGH CITY COUNCIL

The Challenge

Peterborough City is an exciting and growing Unitary Authority. Independent from Cambridgeshire since the 1970's, at which time investment was made in a series of "parkway" dual carriageways, the City has undergone multiple phases of growth and redevelopment since.

As well as adding tens of thousands of houses, warehousing and employment zones, Peterborough City is developing it's offering in Higher Education. For a long time, the City only had a Further Education College, restricting access to education for its residents and failing to draw new, young, educated people to the City. Peterborough was well known instead for industrial vocational training, with Apprenticeship schools and training centres.

Figure 1. Map of Peterborough City Centre (East) from Google Maps

That has been changing for a while, with both the former college being elevated to Higher Education status, with a significant investment in infrastructure, and a new campus from Anglia Ruskin University being built near the heart of the City.

Figure 2. View of Anglia Ruskin University, Peterborough Campus (from Google Maps)

In particular, the Anglia Ruskin University Campus is changing the face of the City, with it's entirely new facilities, built on what was previously open land near the river, on the edge of the City Centre. The £30M investment opened to it's first students in September 2022. This

is just the first phase though, with far more to come as ARU continues to build, expands its offer to students, and recruits.

22 June 2023

Construction work begins on second teaching building

Turf cutting ceremony marks major milestone at ARU Peterborough

Figure 3. Press Release for ARU Second Phase, from ARU Website

Getting People to Places

With the continuing development of the ARU Peterborough Campus, Peterborough City Council had already identified the growing need for additional infrastructure to support the expansion. ARU's own Transport planning identified a need for car parking, predominantly for staff. This creates significant problems though – the campus is already being built over green public space and in an already congested part of the city. Local residents were unlikely to accept further green space being lost for car parking, and there is not the capacity in the existing highway network to carry the estimated thousand extra vehicle trips to the campus anyway.

Instead, building a multistorey car park on the site of an existing City Council car park was proposed and accepted in principal, along with a range of highway improvements including signalling the roundabout next to the car park. The car park is close to the parkway network, which has the capacity for the traffic, and the campus is ideally located for walking and cycling from the City Centre.

Only a few challenges remain:

- How to get the extra traffic from the parkway network into and out of the car park?
- How to link high quality walking and cycling links from the car park to the ARU Campus and the rest of the City?
- And how to do the above, without worsening existing traffic problems on the local roads

This is clearly a strategic challenge; however, it is beset by detailed technical problems. The City Council have adopted LTN 1/20 as the standard for cycling facilities and want it applied throughout the design, while taking Manual for Streets into account as well. Appropriate standards for the highway itself are a mixture of D.M.R.B and TSM Chapter 6. Peterborough generally has excellent long-distance cycling infrastructure but there is nothing existing between the car park and campus. While a mostly-modern City, the route runs directly past the Cathedral grounds, past schools, businesses, and is lined with mature trees.

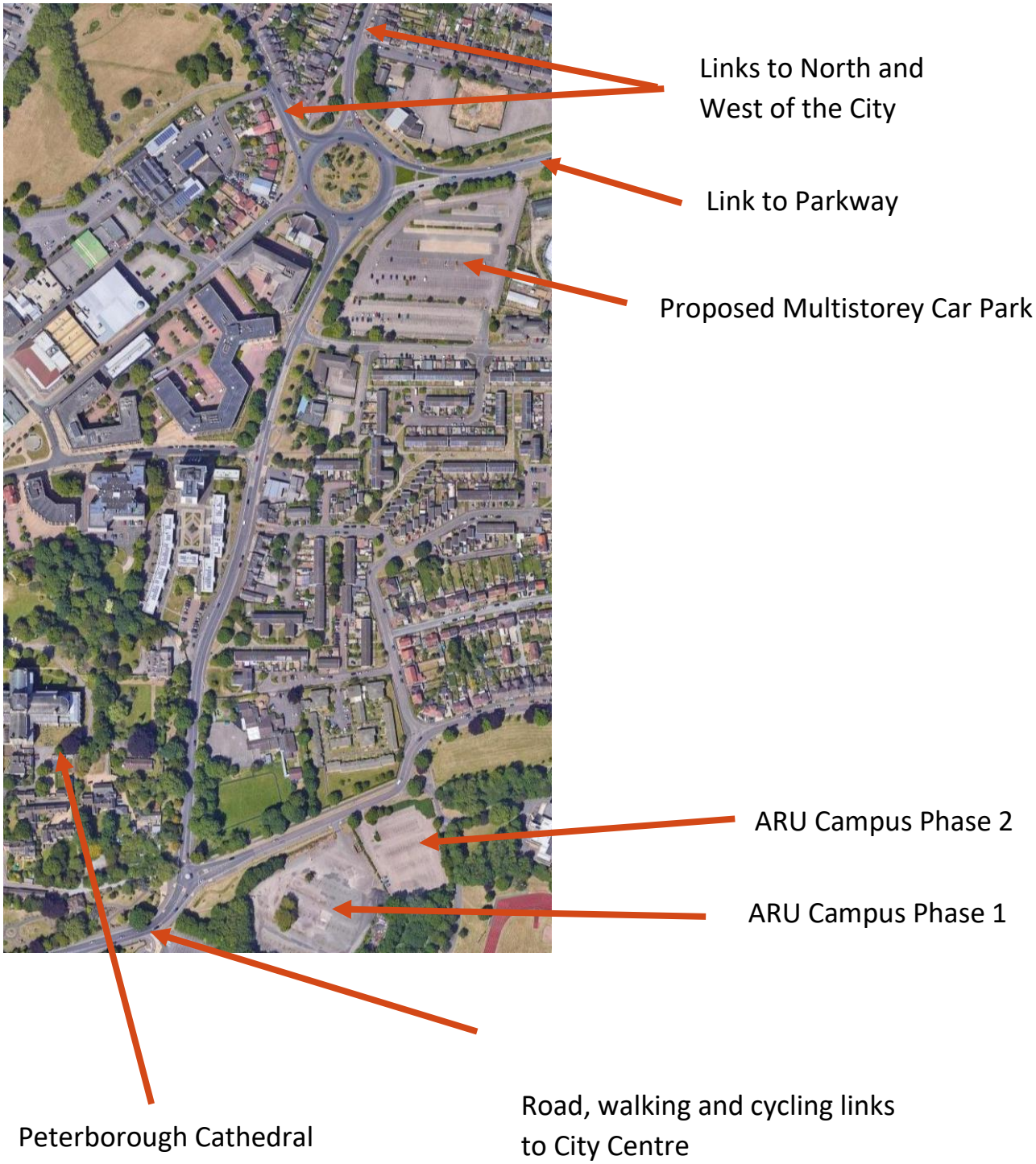


Figure 4. Aerial View of highway network (from Google Maps), with annotations.

Walking and Cycling First

With LTN 1/20 stipulated as the standard for cycling infrastructure, walking and cycling routes were roughly plotted first. There are few residential areas East of the site, so the majority of the City is to the North and West (from the south, access is restricted by the river).

From the West there is an existing high-quality cycleway and footway, connecting to the City Centre and bridges south of the river.

It was most important therefore to connect the campus site via the Car Park to the major residential areas North and North-West, shown in blue below.

This posed a significant and major problem immediately – at the northernmost end of this route lies a (notorious) Roundabout at the bottom end of Eastfield Road. This roundabout is large for a conventional roundabout, has five arms, and is well known as being difficult to both drive and walk around.

The roundabout features two or three lane approaches on all arms, already high levels of traffic, and just a few dropped kerbs in places, even across fast wide approaches.

The existing site clearly does not meet LTN1/20 standards, and it's difficult to see how it could be made to do so. Likewise, the original proposals for simply signalling the roundabout clearly did provide opportunities for walking and cycling that meet the scope.

Figure 5. Aerial View (from Google Maps) showing key walking and cycling routes

Figure 6. View of Eastfield Road Roundabout (from Google Maps)

Minimising Congestion

The next major concern is to minimise or even reduce congestion in the City Centre. This clearly requires the additional traffic to be brought between the Parkway network and new car park as efficiently as possible. But while making that route efficient, the existing routes for residents and businesses can't be cut off or restricted. We also have to recognise that some traffic will be arriving at the car park through the City Centre. Complicating this was talk of "other development opportunities" tied into the car park.

The traffic routes can therefore be broken down into two categories: access to the new car park, and existing traffic routes.

In the Figure 7, the existing through routes are shown in yellow, while new predicted traffic flows are in red.

As can be seen clearly now, all routes lead through the Roundabout.

While significant other work was already underway to increase traffic capacity in other, simpler parts of the road network, including modelling and designing new traffic signals, improvements to existing junctions, new dual carriageway links and other cycling and walking improvements, the Transport Planning Team at Milestone Infrastructure Services and Chris Kennett Consulting Limited decided to look at the roundabout and car park site again, with a "blank slate" approach.

Figure 7. Aerial View (from Google Maps) annotated with key traffic routes.

The Scope

The Principal Transport Planner at Milestone Infrastructure, leading Peterborough City Council's approach to the site discussed the project with CKCL and set out a scope *(paraphrased)*:

"Look again at the whole roundabout – and the area around it. Nothing is off limits. Run through whatever ideas you can think of, test them and either discard them quickly or sketch them up roughly for us to progress and develop further. ***See what works****."*

Traffic flows were provided from existing surveys and future year traffic forecasts.

The Site

Figure 8. Aerial view of development site (from Google Maps), with approximate boundary.

The red line on the above plan shows the approximate boundaries of the site controlled by Peterborough City Council, or expected to become part of a Compulsory Purchase Order anyway. The other improvements being discussed and designed mean that there is no 'hard-edge' to the site extents along the existing highway; the schemes would need to be tied together, but significant differences between existing and proposed would be acceptable during development of a concept.

In particular, Boongate, to the East, is proposed to be widened to dual carriageway for its full length to the interchange with the parkway network. At this stage, while restricted by the need to widen a bridge and change the adjacent structures, no final decision on the design or alignment of the dual carriageway had been made.

Design through Iteration

With the scope established, CKCL had a limited period in which to undertake the work before a concept design was needed.

We put a rapid design iteration process in place:

1. Line Drawing
   Quickly (in a few minutes) hand-sketch a line drawing of where crossing points might run. Then add turning movements and outline lanes for traffic.

   Consider pedestrians and cyclists simplistically and together at this stage.

2. Linsig
   Using a template model with the entries and exits defined and traffic zones and flows entered, modify the model to approximate the Line Drawing. When the model runs, is it at or close to positive capacity? Where are the difficulties in the model?

3. Outline Drawing
   If the modelling suggested the design *might* be made to work, sketch the line drawing in CAD, with basic lane widths and radii. Run AutoTurn through any 'difficult' corners. Is the geometry achievable? Is the solution practical (understanding we need to maximise space for the Car Park and other development).

4. Revise Linsig
   Push the lane details and radii back into the Linsig model. Pull any other details across into the modelling, including adding more realistic details for pedestrian and cycle crossings.

5. Review
   If the modelling still suggests this is a feasible solution, analyse the design and model to identify problem areas, go back to stage-3 and revise the layout to address the problems. If the solution looks strong enough, consider moving on to stage-6.

   If the problems prove fundamental, go back to stage-1 and amend the Line Drawing more fundamentally, to avoid the problem.

6. Client Liaison and Feedback
   With a concept idea looking feasible after the review, it can be drawn up (still roughly) for discussion with the Client, to talk through the implications of the design.

   With Client feedback, be prepared to go back to stage-3 and revise again.

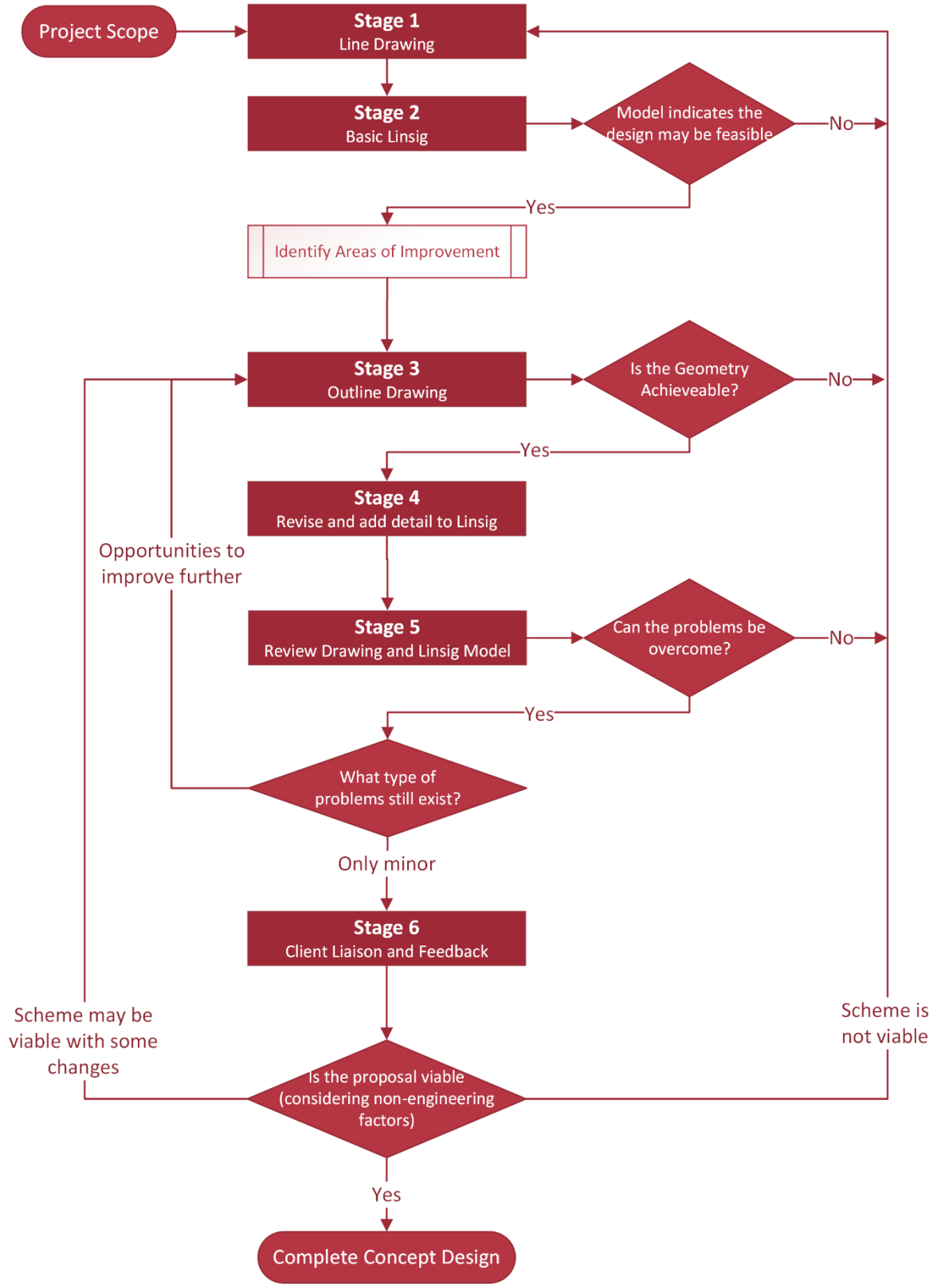


Figure 9. Iterative Design Flowchart

While the process looks complex, it is simple to follow and requires problems to be rapidly identified, and either solved or avoided. Time is not wasted on options that later prove unviable, but each potential solution gets explored in detail through multiple iterations between stages.

Iterating Around

We started the first stages started by using the existing roundabout footprint, with minor widening or changes offline. Partially and fully signalled roundabout options were looked at and quickly dismissed. All options to use the existing roundabout struggle to provide sufficient capacity, while there is insufficient physical space to create the high quality pedestrian and cycle infrastructure.

Internal queues on the circulatory movements rapidly become a problem when pedestrian crossings are added over exit lanes – something often overlooked when designing such sites. With crossings only across signalled stop lines, the desire lines for walking and cycling cannot be met well enough to make them attractive routes.

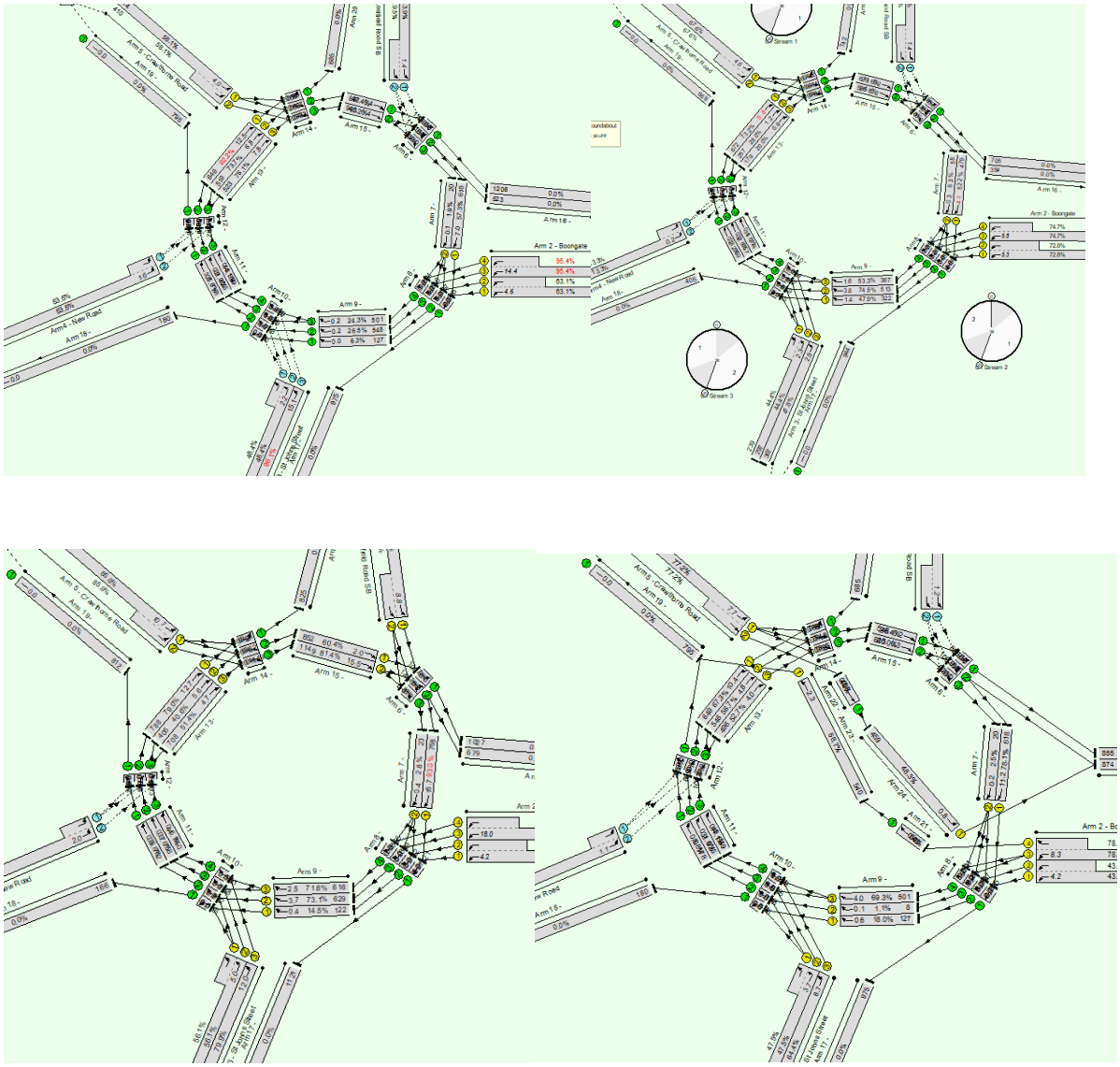


Figure 10. Iterations of Linsig Modelling

These options are barely sufficient on all counts – from a walking and cycling perspective, they are indirect – and from a traffic perspective they are at or over capacity.

While theoretically viable designs, the "experience" they offer is likely to be negative. While they ***allow*** pedestrians and cyclists to cross the difficult and dangerous roundabout, they do not ***encourage*** walking and cycling.

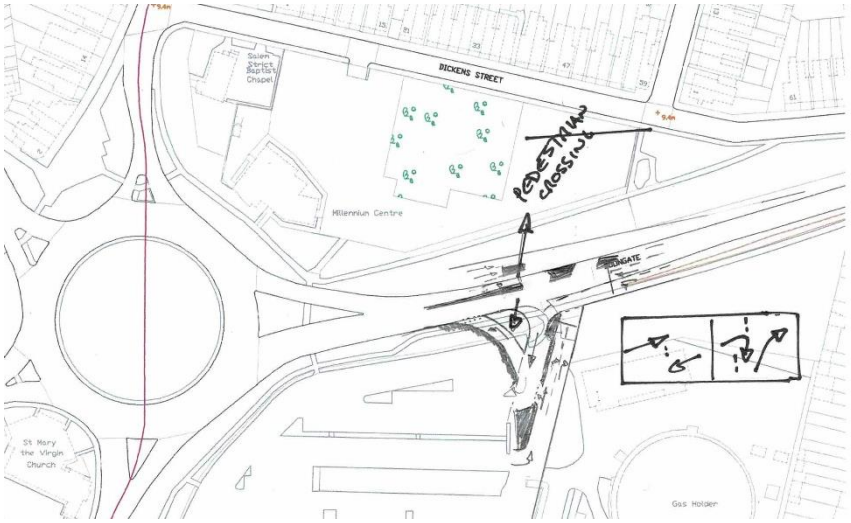
These options did not get past stage-2.

The scope of the brief allows us to go further.

Taking Traffic Out

The modelling showed us that the physical layout of the roundabout was at capacity, no matter what we did with it. The geometry of a roundabout is not ideal for walking and cycling, as it takes people off their desire lines.

Tackling the problems in those designs, could we remove some traffic, pedestrians and cyclists from the roundabout entirely, by passing traffic to the car park directly from the new dual carriageway?



This idea added an extra junction to the east of the roundabout, displacing the right turn out of the side road to create a highly efficient small junction.

Figure 11. Stage-1 Line sketch of potential junction layout

An interesting idea? It seems to work in isolation, but the roundabout is still a problem for cycling and walking, while it is also hard to contain queues between the roundabout and new junction.

Removing the Roundabout

Back to stage (and square) one again for the time being.

After dismissing large five or four arm junctions through the same process (too complex to achieve the standard of walking and cycling, while maintaining capacity), replacing the roundabout with a staggered junction shows some promise – enough to advance to stage-3.

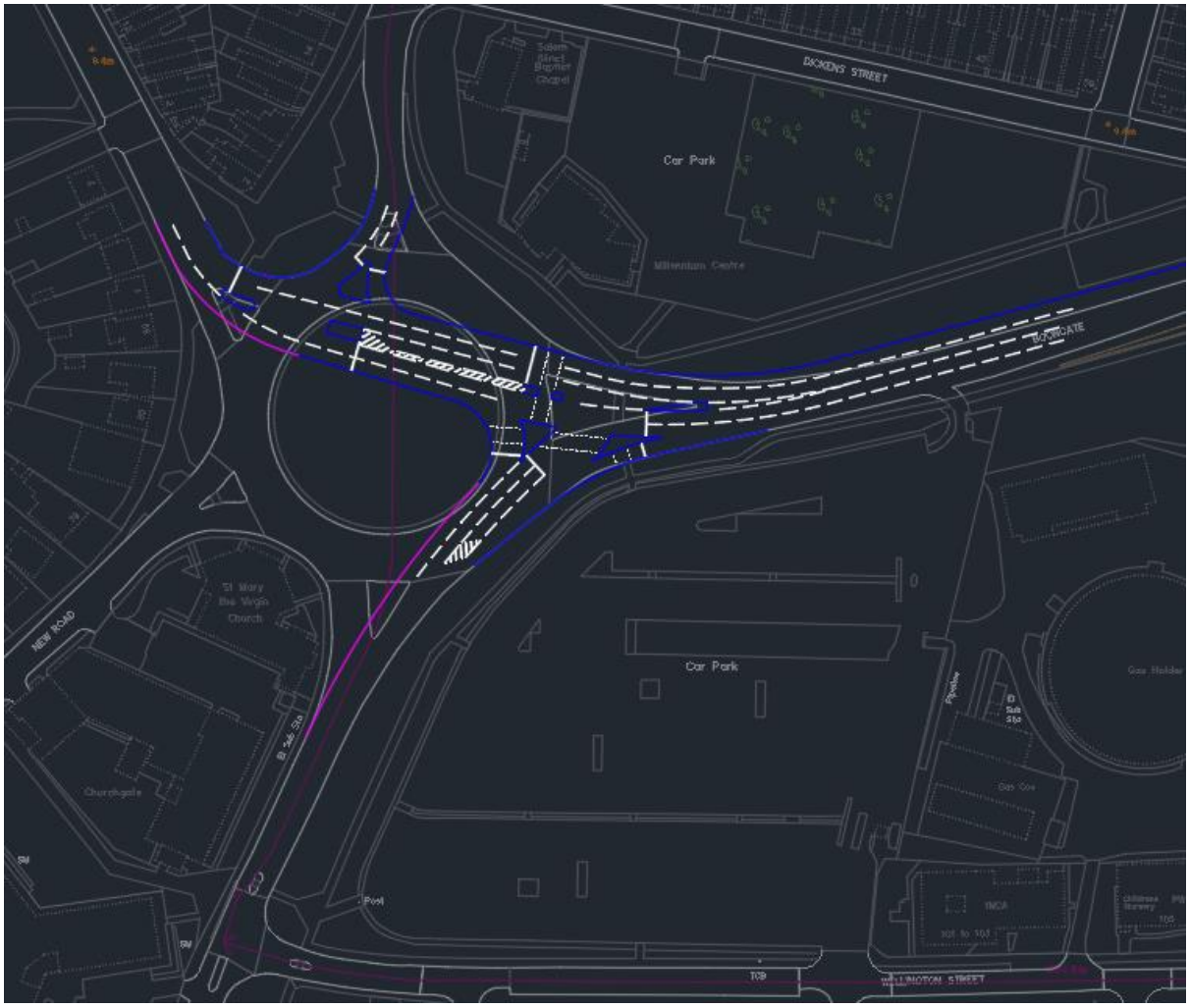


Figure 12. Stage-2 Outline CAD drawing of a potential design

In this example, the minor arm, New Road, is cut off entirely and assumed to be served from other routes. Likewise, crossings on Crawthorne Road (to the west) and Eastfield Road (to the North) are assumed to be remote crossings, away from the junctions. Although lining is shown, lanes have just been quickly created using fixed offsets and typical radii. Islands fill the gaps between lanes, allowing the approximate paths of crossings to be determined.

Only at this stage can we see for the first time that there is little space for walking and cycling: the crossings in the junctions are long and need islands for pedestrians, but the islands are too small to segregate cyclists from pedestrians.

The layout is still heavily dependant on the previous work – crossings follow the paths of the stage-1 line drawings, while being arranged to allow of the efficient stage order from the stage-2 Linsig model. The Linsig model is refined in stage-3 using the new geometry.

Problems and questions remain with this. Moving on to stage-4 for the first time, pulling more detailed and realistic detail into the model, we found problems with the traffic flow between the South and West, with queues on the internal links again which cannot be contained within the network.

This version also has weaknesses in the walking and cycling infrastructure around the northern and western arms, as well as an unresolved question around access to New Road.

Digging into these problems, we found we need three things:

- Even more space for walking and cycling,
- Additional walking, cycling and road links to the west,
- Greater separation between the northern and southern arms.

And so once again, we roll back a few stages and look again.

Working through the Options

Back to the drawing board and working through iterations of line drawings, Linsig models and then outline sketches, to slowly develop a workable concept.

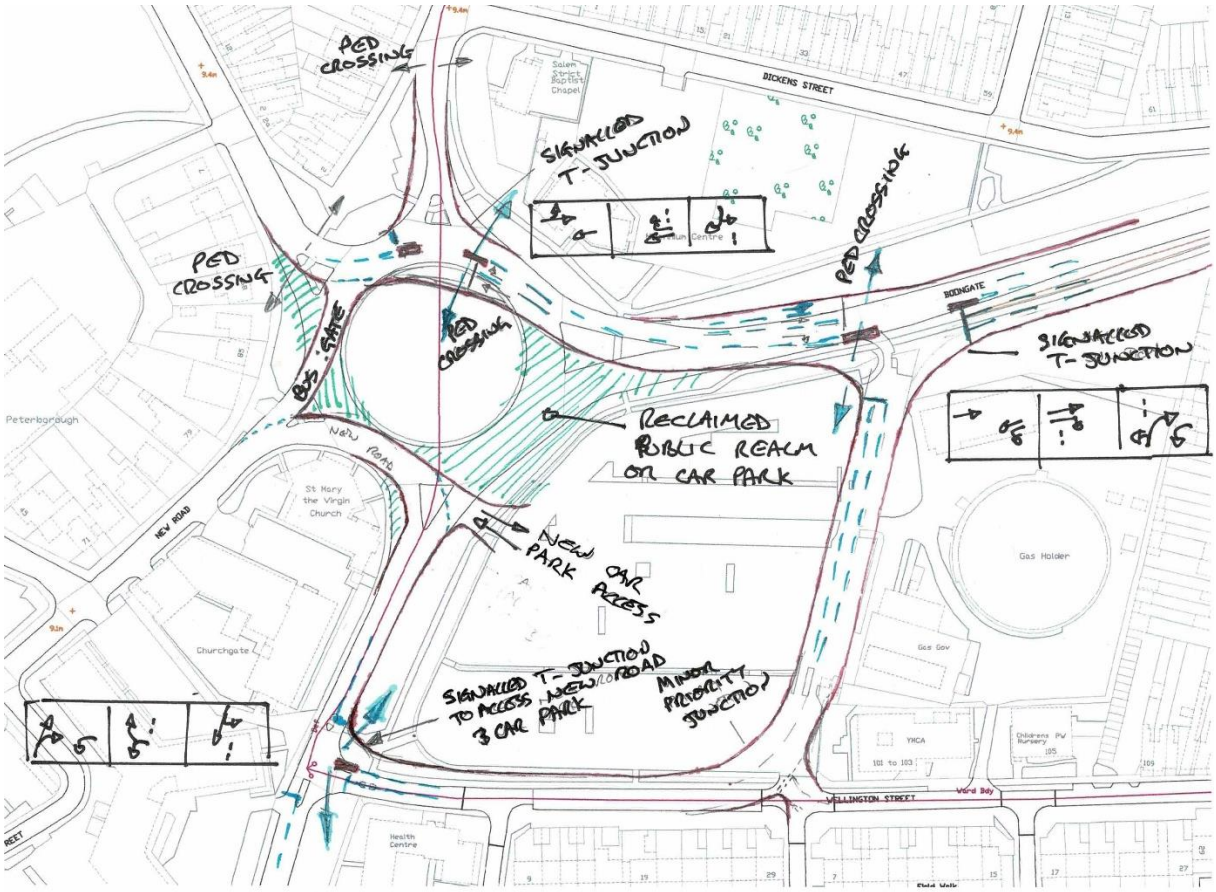


Figure 13. Stage-1 Line drawing of potential highway network and junctions.

This line drawing first explored the concept of re-aligning the road around the edge of the site. Crossings are still shown just as indicative lines, running through the expected important desire lines identified earlier.

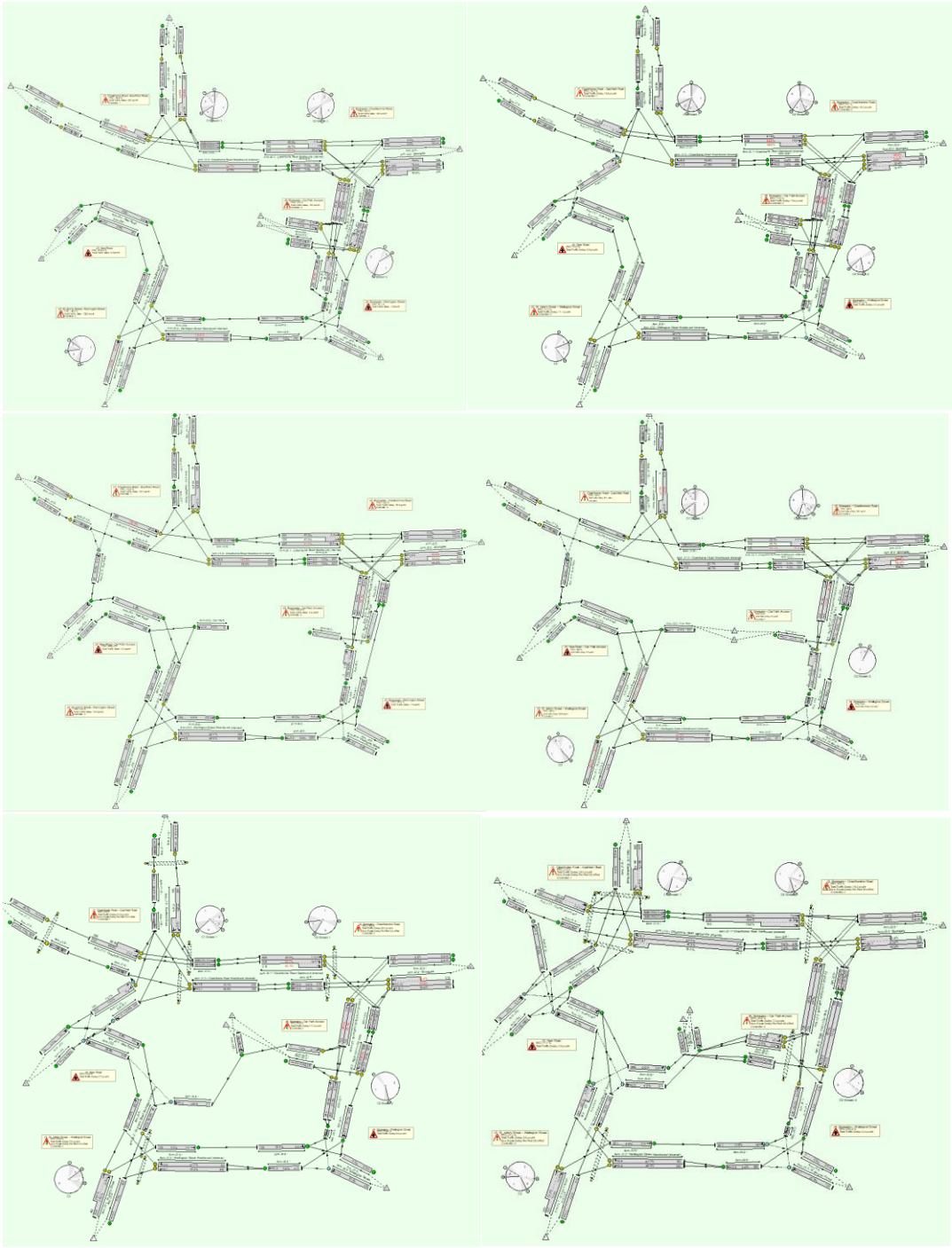


Figure 14. Stage-2 Iterations of Linsig modelling for variations of highway networks.

The options make varying assumptions about distances between junctions, include increasing levels of detail about crossing facilities, and various limitations on turning movements, one-way limits etc. Each is tested, examining in closer and closer detail the implications and impact of each change on the rest of the network.

Along with each version of the model, the outline drawing is modified, looking to ensure the facilities needed can be achieved - opportunistically identifying and including improvements wherever they can be found and rolling those back into the next Linsig revision.

In the examples above, the progression of pedestrian and cycle crossings can be seen, with few details included in the earlier models, increasing in detail through the iterations and being pulled into the preferred locations wherever possible.

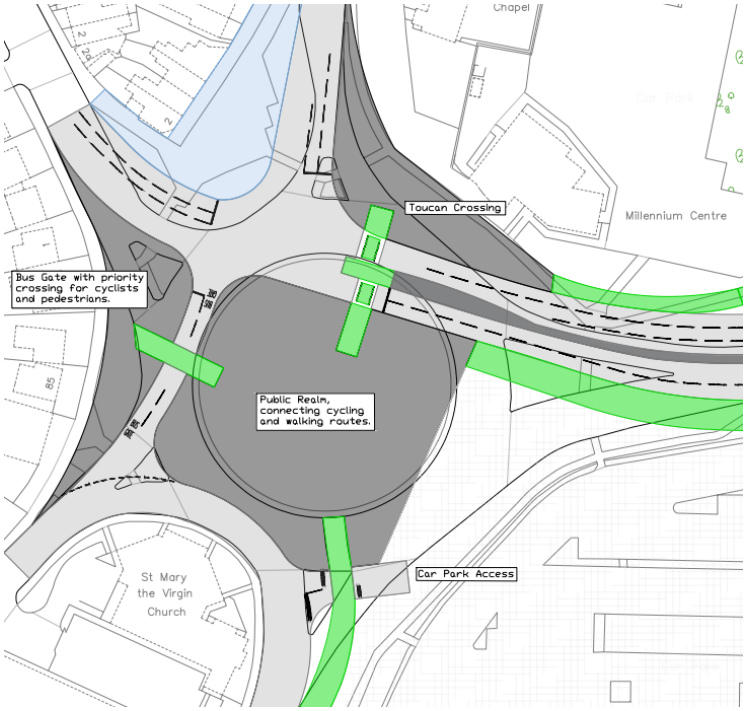


Figure 15. Stage-6 working drawing for discussion with Client

Even the concept of how the spaces created could be used is considered as the design development continues. Creating wide open public realm spaces was considered, with shared toucan crossings being appropriate under Manual for Streets and LTN 1/20. Bus gates were considered and turning movements restricted.

The Client is engaged with this process, with the progress and concepts developed to stage-6 being discussed.

As the iterations progress, concepts for more direct cycle tracks developed. Segregation has been previously looked at and now becomes simpler to achieve.

It should be noted that this is a deliberate part of the iterations – each version is as much driven by the need to achieve the desired quality for walking and cycling as it is capacity. This approach demands both, accepting compromise but not sacrifice.

By working through in this way, making small iterations to the models and designs, checking where the problems are and addressing them – and, importantly, being prepared to step back if it doesn't work well enough – we end up with potential solution.

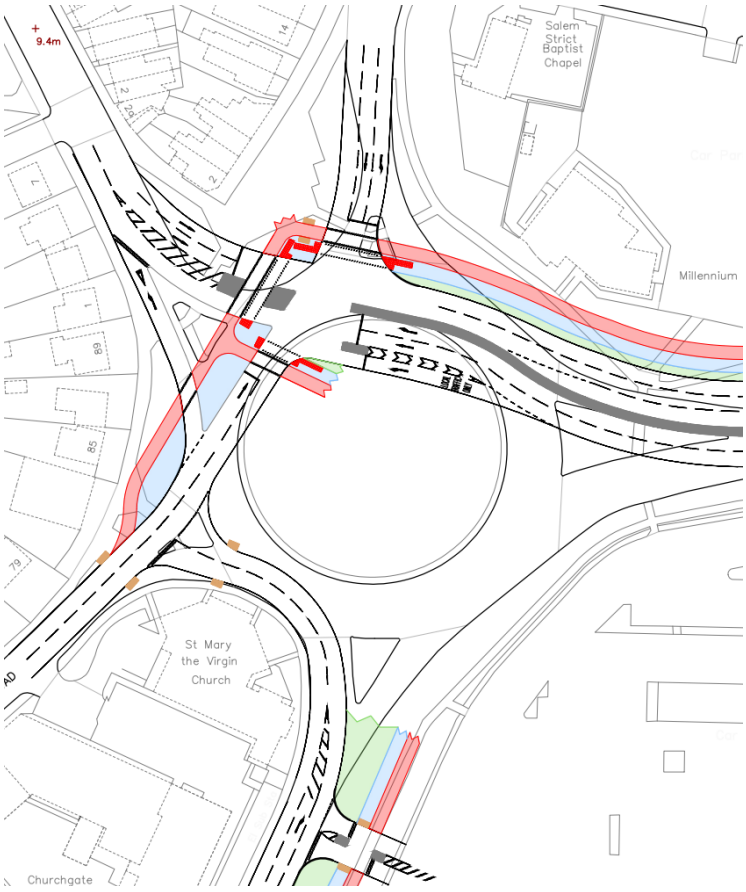


Figure 16. Concept Design Drawing for western road network, including second (minor) car park access.

Concept Design

The end result of the concept development has been a radically different road network to the existing roundabout, creating a square(ish) road network and opening up the central area fully.

A new road around the edge of the site carries the majority of traffic between the parkway network, new car park, and into the City Centre.

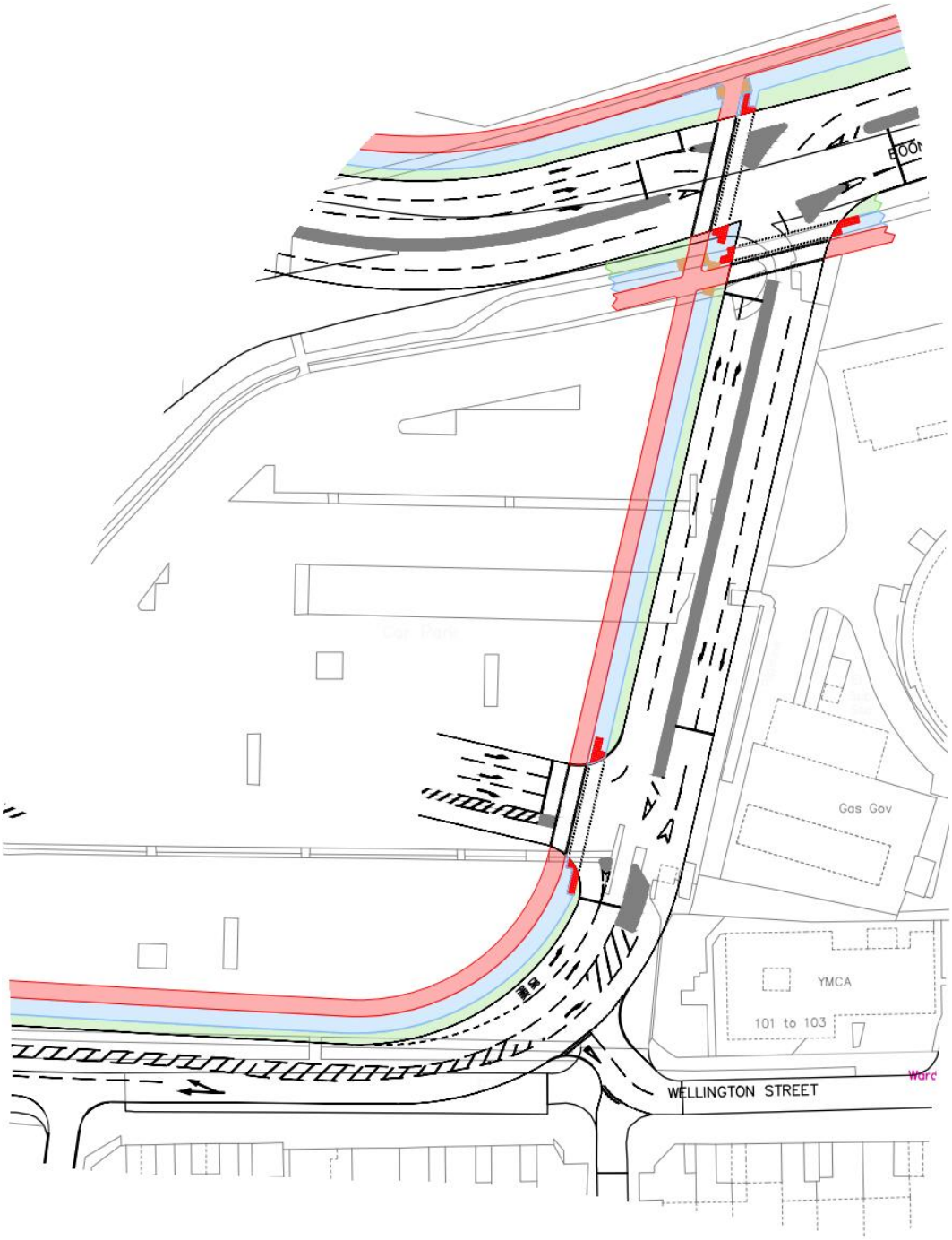


Figure 17. Concept Design of Eastern Link Road with Boongate and Car Park Junctions

High quality segregated footway and cycleways follow the road, providing direct links from the ARU and the City Centre to the South, with the North-East of the City.

By taking the road around the outside of the site, a single large internal area is created for the car park and potentially for retail and public realm uses. The design and nature of the road – urban dual carriageway – is in keeping with it's use and location, following the principals of Manual for Streets (1 & 2), while the off-road but segregated cycle facilities meet LTN 1/20.

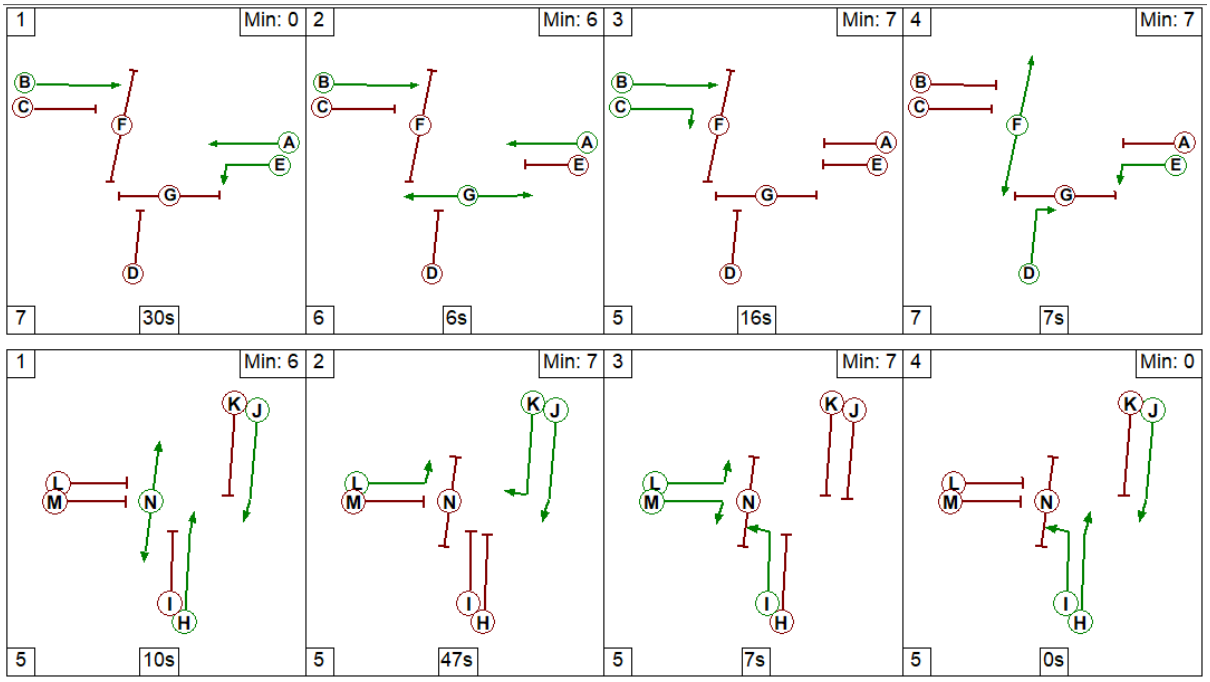


Figure 18. Stage Diagrams for Boongate and Car Park Junctions

The junctions provide high capacity for efficiently moving the large volumes of car traffic, while simple staging and a few restrictions on minor turning movements, provide direct crossings, with no staggers – particularly good for cycling.

Further banned turns and use of "hold-the-left" accommodate direct crossings, without the need for slow and inefficient all-red stages. The phase and stage design for each junction considers the likely pedestrian and cycle flows, with the busiest crossings expected to run longer – for example, running in the revertive stage. Quieter crossings are still direct but may only run for their minimum – although they could be extended by cycle detection or volumetric detection.

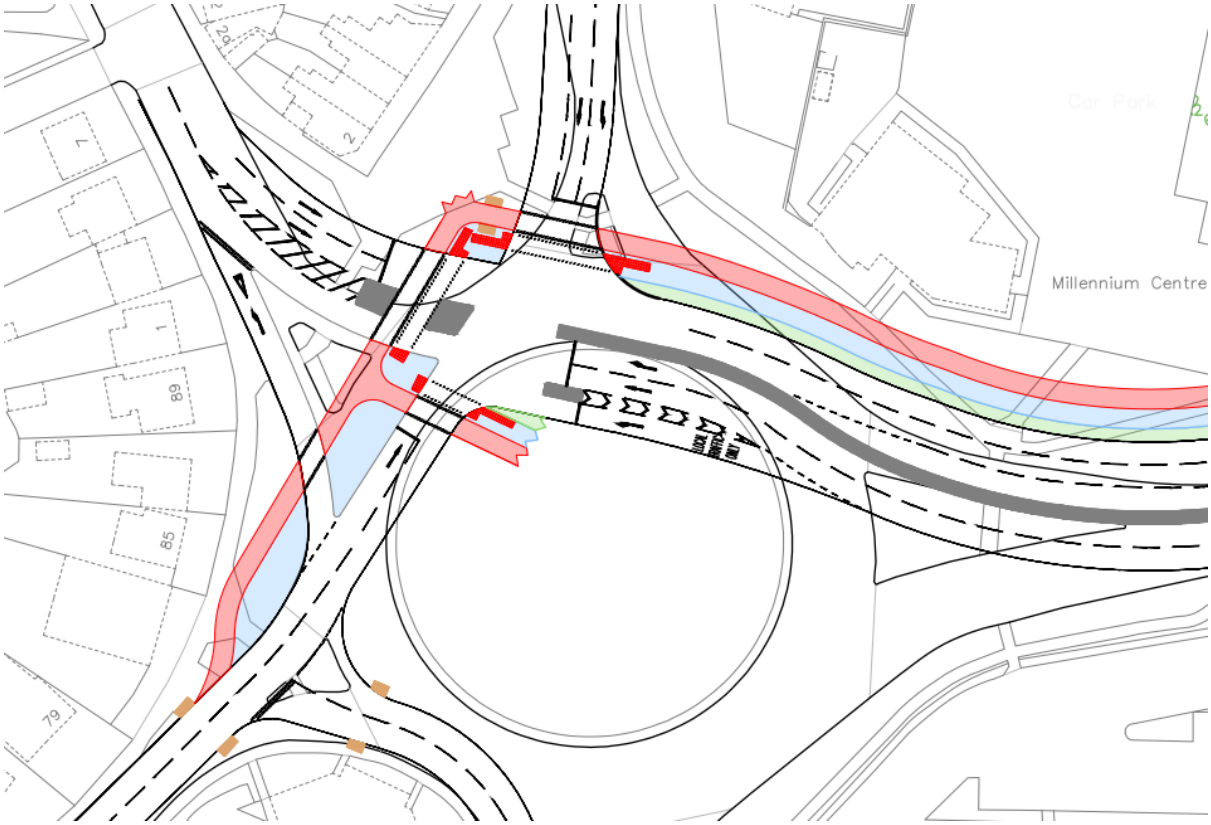


Figure 19. Concept Design of Eastfield Road - Crawthorne Road Junction

By maintaining the minor arm to and from New Road, but designing it to manage speed down and applying further restrictions, the road becomes only useful for local traffic – removing the need for them to use the larger roads and junctions to the east.

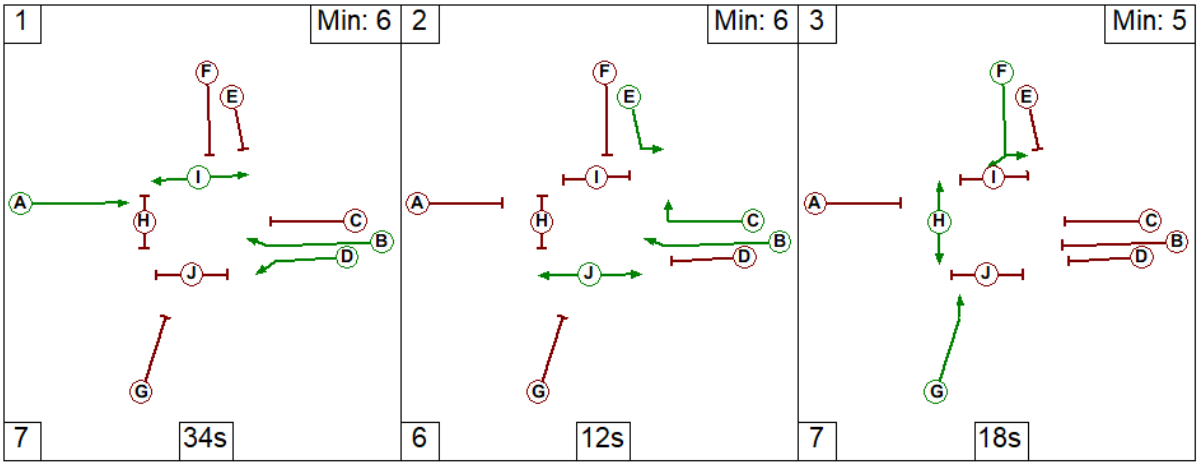


Figure 20. Stage diagram of Eastfield Road - Crawthorne Road junction

The restrictions remove opposed turns and keep the stage order simple. They also manage the routes people can use, connecting the roads used for local traffic together, and connecting the through routes together, but stopping people from using local routes as rat-runs. Even the hold-the-left helps in this regard, by adding delay to a potential rat-run, encouraging traffic to use the proper route.

Again, this maintains the principals of Manual for Streets, this time by reducing traffic on the minor roads used for residential and retail. These areas to the west are more important as places, and the design reflects that, tying the cycling and walking facilities into quiet roads and shared spaces.

The central area is still left open to allow options for it to be developed, but the concept of connecting the walking and cycling routes is clearly indicated – by whatever means.

To the south of this new network, a further junction links the through-routes (from South to East) with the local links (to the North and West), and provides an alternative car-park access, again allowing local traffic to be kept separate. And the direct, high quality and segregated footway and cycleway cross directly through the junction, connecting to the route south, to ARU.

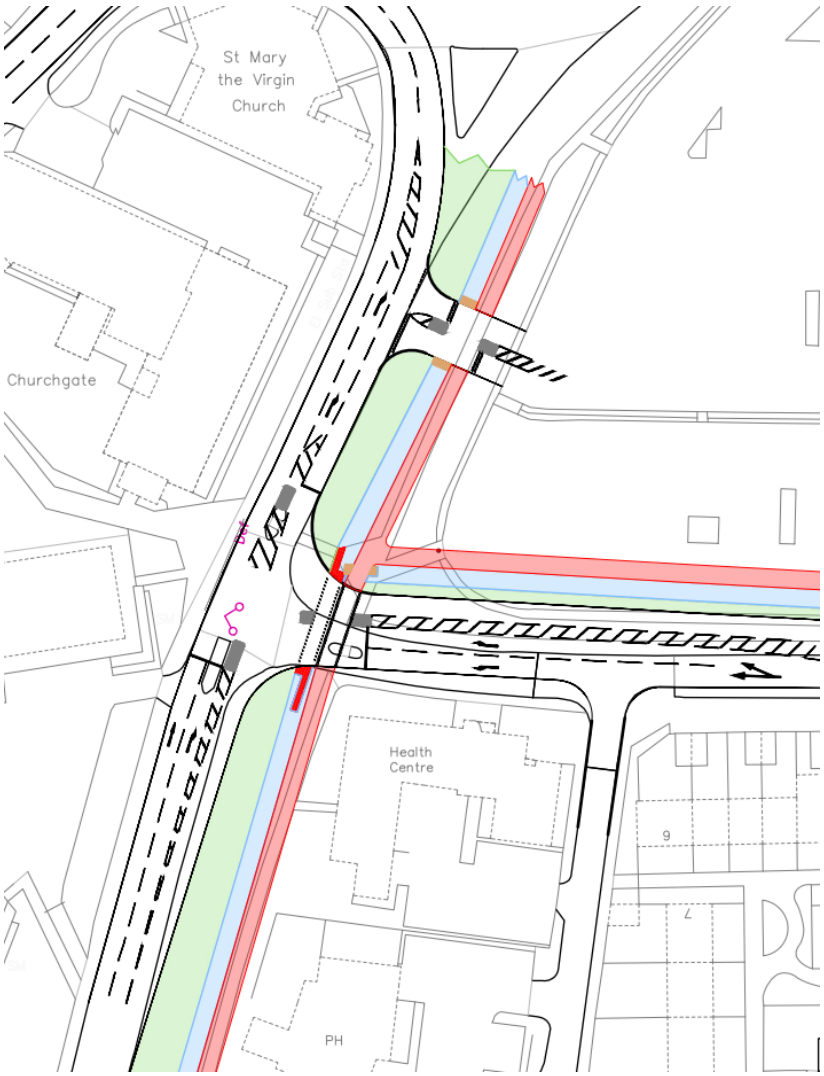


Figure 21. Concept Design of St Johns Street Junction

Going Further (Conclusion)

The concept development work was tested by Milestone using Microsimulation and the results were confirmed, with further information gained about potential traffic flows and route choices. The microsimulation was also used to develop the wider road network and scope for dual carriageway widening and other junctions.

In total, the area covered by the project includes seven new junctions, widening and refurbishment of an eighth junction; replacing a toucan with a segregated pedestrian and cycle crossing, one new Puffin and one further refurbishment of a Puffin.

Outside of traffic signals, there are several miles of new cycleways, changes to priority junctions, bridge widening and additional dual carriage way.

All of this works together to form a comprehensive network of improvements moving people into and around the eastern edge of the City Centre, encouraging people to walk and cycle, but accommodating those who need to drive.

The package of measures and modelling was strong enough for the first stages of the business case to be approved, and funding unlocked for progression to Preliminary Design.

Still Changing

Throughout, the key to optimising the design has been a willingness to revisit design elements and revise them if a better way can be found: this continues in Preliminary Design.

As the highway alignments have been progressed, some crossings have become too long for pedestrians – the solution has been to split the pedestrian crossings, while keeping the cycle crossings direct. The timings for cycle crossings are all calculated using the dedicated cycle times in Traffic Signs Manual Chapter 6, avoiding unnecessarily long intergreens.

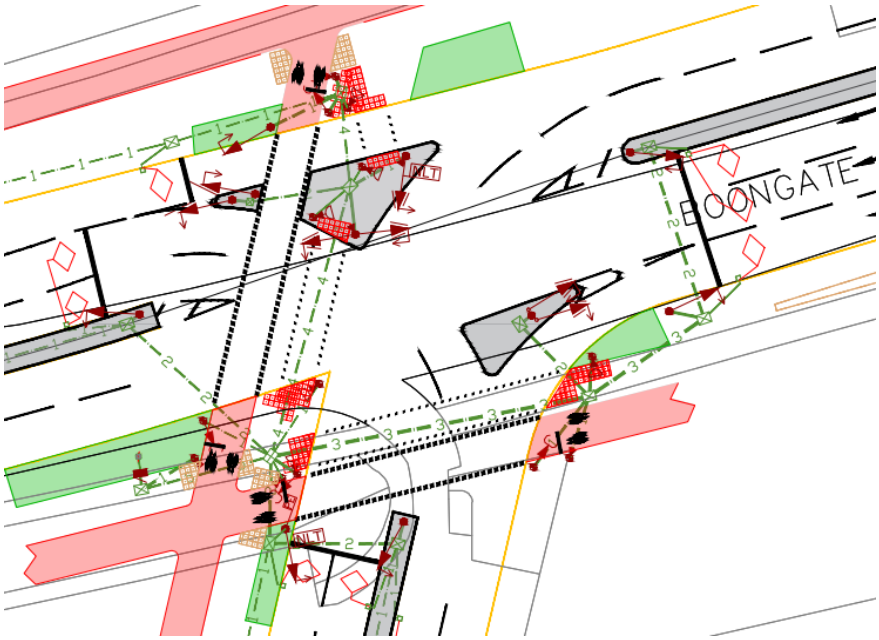


Figure 22. Preliminary Design of Boongate Junction

One cycle crossing (across the southern arm) may be removed from the design entirely, as the onward route cannot be made suitable for cycling. An alternative route is better suited and will be improved further – this is following the principals of providing continuous high-quality routes instead of fragmented and partial facilities.

While the highway network proposed looks complicated, most traffic is routed away from residential and commercial areas – the majority of traffic is quickly and efficiently directed

to the right places, and the highway network rapidly gets smaller and more attractive as traffic flows drop and pedestrians become more frequent.

Traffic signal poles have been kept as short as possible, so even the largest junctions have just a few four-meter poles, and no tall poles or mast arms. Nearside display units and low-level cycle aspects for cyclists can be mounted on a mixture of 2, 2.4 and 3m posts, minimising visual impact. Crossings are optimised for the people using them, with pedestrian crossings being kept shorter, but cyclists more direct.

Challenges and Lessons

One important lesson to understand is that that this process was not necessary to get a ***viable*** design. We found multiple viable designs throughout and discarded or developed them. The reason for introducing this process was to identify the ***best possible*** solution(s). The early 'viable' schemes (before the iterative process) simply did not pass the business case: conventionally adding cycling facilities through the existing junctions destroyed too much traffic capacity; conventionally adding traffic capacity did not provide good enough cycling facilities for the schemes to be worthwhile.

Many of these schemes were viable though, if the downsides had been covered up or the scope had been reduced, and these factors had been removed from the business case. This is what often happens and is one of our biggest challenges in providing truly high-quality facilities.

The old adage is true: "you get what you pay for". In this case, Peterborough City Council were willing to invest the time at design to find and achieve a much higher rate of return on the eventual scheme, rather than accepting major compromises early on and losing the benefits.

The rapid iterative process was more time consuming initially, but the solution found was of high quality and further changes to the scheme have been minor and evolutionary. When the risk involved in design work – for example the later business case failing and the concept needing to be revisited – is factored in, iterative design is no more expensive, but can achieve much greater results.

Squaring the Circle

The designs developed through this process will result in the removal of an unpopular large roundabout, with a significant accident problem and no meaningful facilities for walking or cycling.

Instead, a radical new highway network will be created, focussing on getting the right people to the right places, using the right routes. The design has been optimised for all modes of travel, and will provide excellent walking and cycling links from outside of the City, right up to the new ARU campus.

Traffic capacity has not been compromised to achieve these facilities – instead, substantial new capacity is created to enable the development, but no spare – the new capacity is capped to match the existing levels of spare capacity.

And air quality is maintained by taking using an efficient road network and keeping the majority of traffic as far away from the City Centre and residential areas as possible.

Compromises have had to be made, but compromises and restrictions have been used to enforce the key principals driving the design, not detract from it.

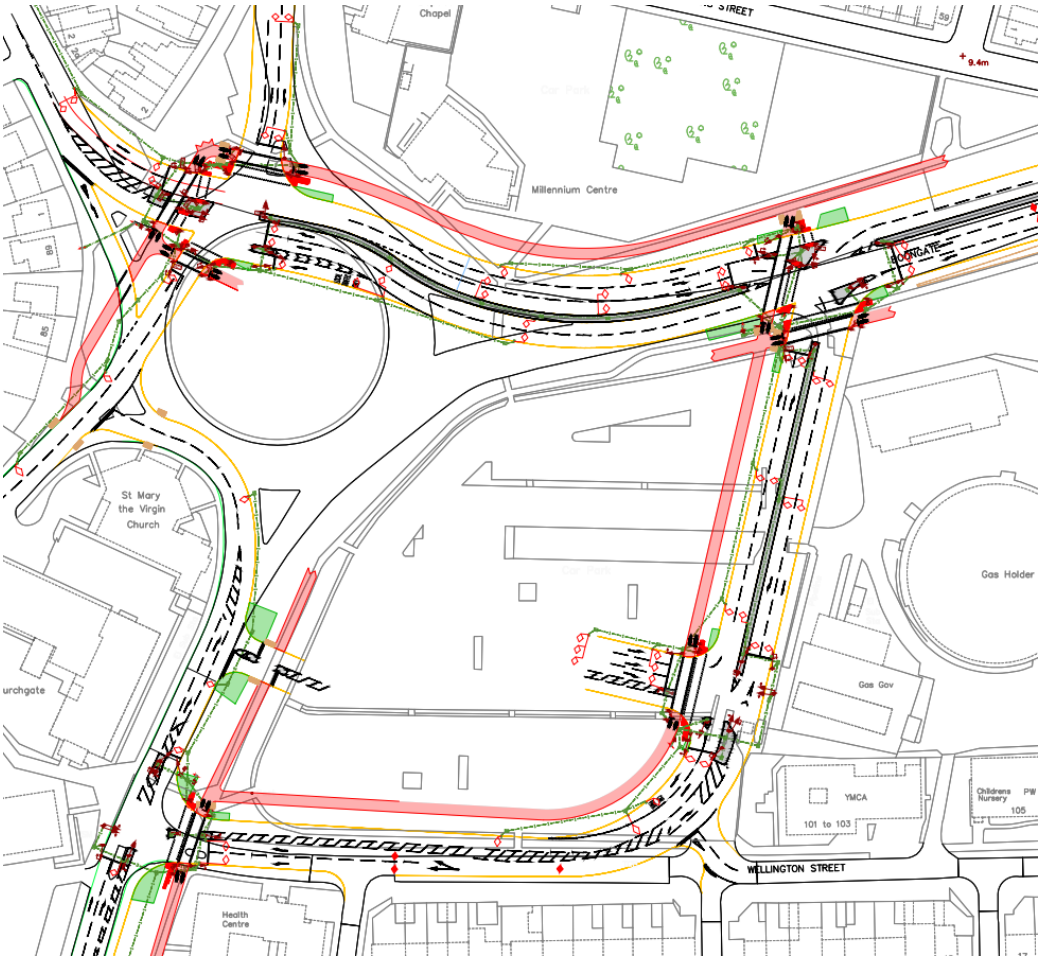


Figure 23. Overview of "Junction 39" proposed network.

This has all been possible through the willingness of the Client (Milestone and Peterborough City Council) to engage with this flexible design process by providing a wide, output based scope and allowing – asking for – creative ideas.

It is this flexible design process that has produced such strong results and concepts. Being prepared to change or abandon even the good ideas and work done so far, if it doesn't fit the wider scheme, results in an overall much higher quality scheme.

The cost of this type of flexible an iterative approach is initially higher than progressing each design in a fixed and independent process, but has probably overall saved money as repeated microsimulations have not been needed. And the quality of facilities, along with the consistency achieved along the routes is rare to achieve, without sacrificing traffic capacity.

Next Steps

The Preliminary Designs are now being finalised and the business case for the highway works is being updated for approval later this year. Detailed design is expected to start in 2024, with construction of the improvements from 2025 and taking up to five years.