A303 Countess Roundabout

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September 2011

Innovation and Integration

Mott MacDonald

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Content

Executive Summary

This paper has been produced as a scheme example for the 2011 JCT Traffic Signal Symposium at Warwick University, by Alistair Gollop, Senior Traffic Signal Engineer for Mott MacDonald.

The paper is about the Countess Roundabout, which is situated in Wiltshire, directly on the mainline carriageway of the A303 trunk road. It is the first interruption to westbound traffic on the route from London and the Home Counties to the West Country.

A safety scheme was commissioned to reduce the accident rate at the junction, which identified that the most effective measure would be to signalise the operation of the roundabout. In addition to that scheme, two separate packages of works for the replacement of the street lighting and drainage / pavement had also been approved. It was therefore decided to undertake the packages of work together.

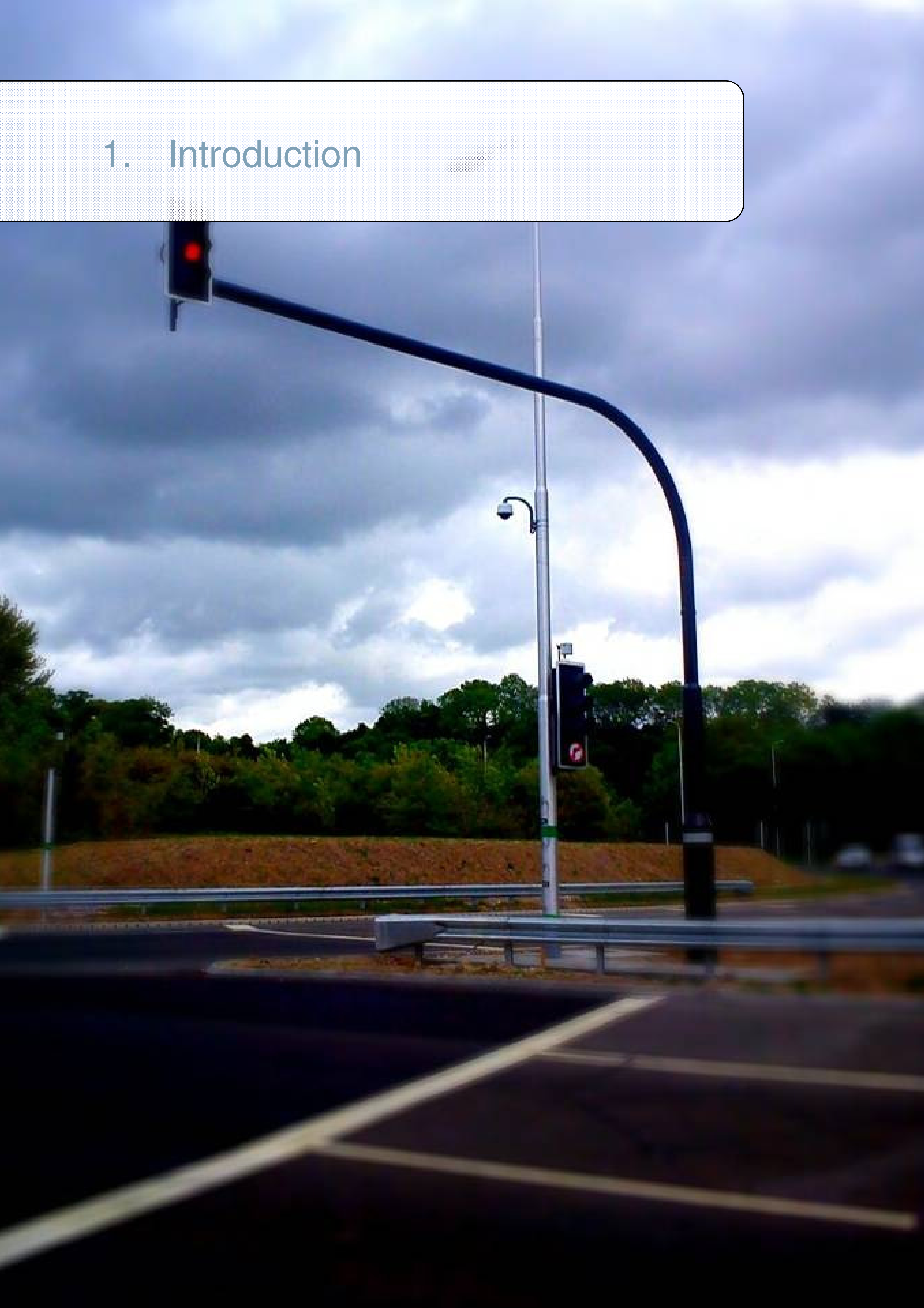
The traffic signal designer took the opportunity to work in close liaison with the other teams to produce a design which benefitted from the opportunity to share features, in order to rationalise the build, to improve safety by reducing roadside clutter and to offer a cost benefit by removing the duplication of equipment.

The roundabout also suffered from chronic exit blocking on the westbound carriageway, caused by the dual carriageway section ending one mile downstream from the junction. The seed point for the congestion is at the merge-down, where two lanes reduce to one on the subsequent single carriageway section. The resultant queue would stretch the mile back to the junction, where it would cause the roundabout to grid lock. The ensuing congestion would not only affect the neighbouring road network, but would also cause the westbound approach to queue for several miles. The new traffic signal design therefore needed to tackle this issue as an integral part of its operation.

The paper investigates a range of issues which were tackled during the course of the work, from design considerations, through construction, to commissioning and validation of the finished scheme.

Although it is too early to study updated accident data, early indications show that the scheme has more than successfully improved safety whilst simultaneously improving junction efficiency under the different traffic conditions experienced at the site. The environment has also benefitted from the improvements to the junction and the aesthetics of the scheme will be an enhancement to the neighbouring Stonehenge World Heritage site.

1. Introduction

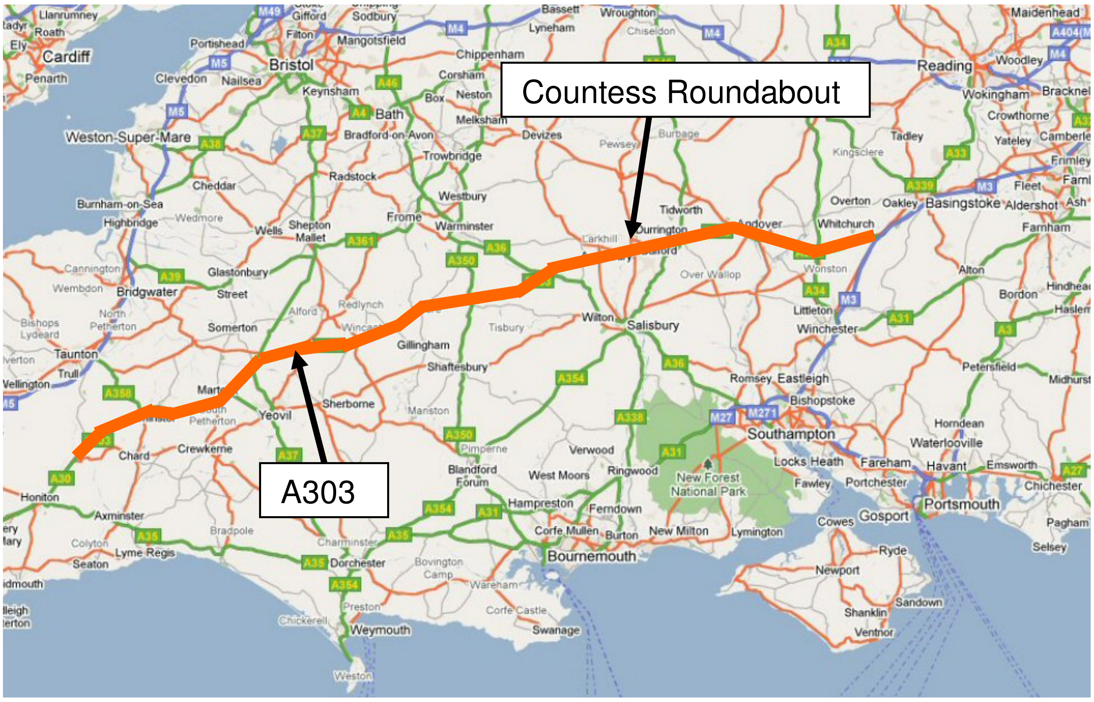


The A303 Countess Roundabout is located in Wiltshire, adjacent to Amesbury. The roundabout is on the Highways Agency trunk road network, and is the responsibility of the Area 2 Contract.

1.1 Location

The A303 starts at Junction 8 of the M3, just south of Basingstoke in Hampshire, and runs west toward Exeter, finishing just over 90 miles later, near to Honiton, where it rejoins the A30.

A303 Route and location of Countess Roundabout



Source: Ordnance Survey.

The M3, A303, A30 trunk route is a major link to the West Country, popular not only with holiday makers from London and the Home Counties, but also with a high proportion of HGV traffic.

The A303 (which is a mix of dual and single carriageway sections) starts in the east as a dual carriageway, with the Countess Roundabout located after nearly 30 miles. The roundabout is situated on the mainline carriageway, and is the first interruption to westbound traffic flow on the route. Beyond the junction, the dual carriageway continues for a further mile, before reducing to a single carriageway section, near to where it passes Stonehenge. The four armed roundabout, consisted of two lanes on the circulatory carriageway, with two lanes on the A303 dual carriageway approaches and egress and with flared approaches on the A345 Countess Road.

1.2 Safety

The design of the roundabout, which was originally constructed in the 1960's, was implemented to allow for the possibility to grade separate the junction at a later date, possibly during the construction of the envisaged continuation of the dual carriageway section westward. Because of its geometry, the roundabout has an elongated central section which resulted in high circulatory traffic speed. In addition, with little horizontal deflection on the mainline carriageway approaches to the roundabout, coupled with the national speed limit (70mph), resulted in encouraging high entry speeds. [NB: Although a system of street lighting on the last approximately 100 metres of each approach to the roundabout should have theoretically restricted speeds to 30 mph, this was not signed and driver behaviour demonstrated that the majority continued at the same speed through this section.] These issues resulted in difficulties for many drivers on the A303 approaches in gap acceptance because of an inability to accurately determine the speed of traffic on the circulatory carriageway.

A303 Countess Roundabout – Aerial view before the scheme

Source: Google Earth Pro, License No. JCPMHB1Z8TSC86H

Personal Injury Accident records for an area within a 200 metre radius of the roundabout centre, for the five-year period from 1 January 2003 to 31 December 2007 are summarised below.

	Accidents				Casualties			
Year	**Fatal**	**Serious**	**Slight**	**Total**	**Fatal**	**Serious**	**Slight**	**Total**
2003	0	1	4	**5**	0	2	7	**9**
2004	0	0	11	**11**	0	0	14	**14**
2005	0	0	7	**7**	0	0	8	**8**
2006	0	1	3	**4**	0	2	6	**8**
2007	0	0	5	**5**	0	0	5	**5**
Total:	**0**	**2**	**30**	**32**	**0**	**4**	**40**	**44**
Average, per annum:	0.0	0.4	6.0	6.4				
Severity Index:				6.3%				

Over the course of the five year accident study period, two serious incidents resulted in four serious injuries. This was accompanied by 30 slight incidents with 40 resultant slight injuries.

Examination of the accident data revealed that:

- 67.5% of incidents were shunts
- 74.2% occurred in dry weather
- 38% were located on the A303 approaches

The results revealed that the majority of the incidents which occurred were shunt type accidents. The causal factor was found to be drivers on the approaches to the roundabout hesitating or braking suddenly, due to their inability to correctly judge the speed of vehicles on the circulatory carriageway.

Previous attempts to curtail vehicle entry speeds on the mainline carriageway approaches had included the use of transverse bar markings and screens mounted in the central reservation to limit visibility of the opposing traffic. However, it is clear from the accident data that these were not successfully overcoming the issue.

A303 Westbound approach – before scheme

A303 Westbound approach – aerial view before scheme

Source: Google Earth Pro, License No. JCPMHB1Z8TSC86H

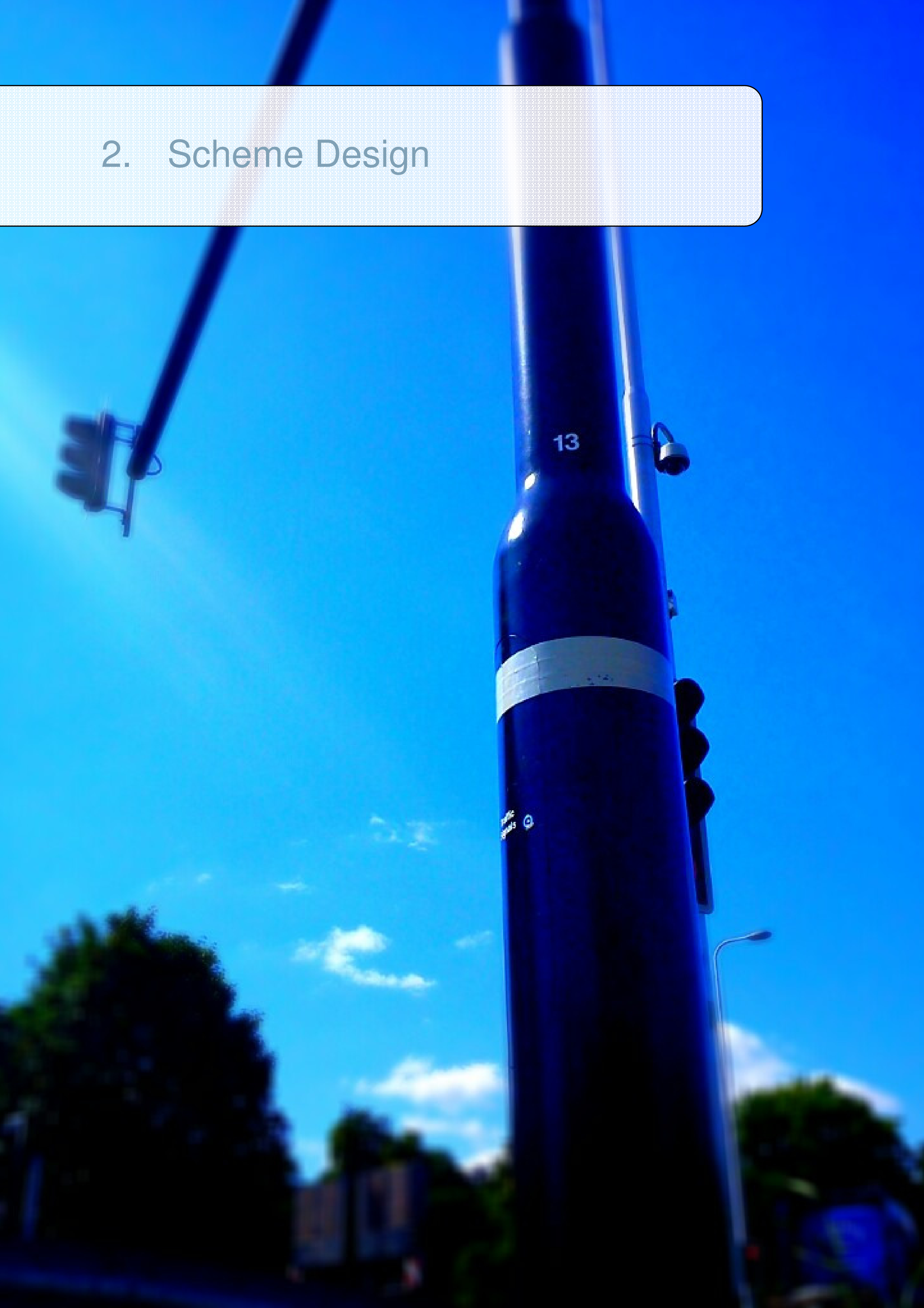
Experience at Podimore, a similar roundabout further west on the A303, showed that the introduction of signalisation could have a dramatic affect on the safety of the junction. Podimore had suffered as the worst accident cluster site on the A303, until 2005/06 when it was signalised. Since completion of that scheme a dramatic decrease in recorded accidents at the roundabout is believed to be due (in large part) to the reduction in circulatory speeds resulting from the operation of the traffic signals.

1.3 Congestion

In addition, Countess Roundabout also suffers from chronic exit blocking on the westbound carriageway. The dual carriageway ends one mile west of the roundabout, where the reduction in capacity which occurs at the merge-down, at the point where the two westbound lanes reduce to one on the single carriageway section, causes flow breakdown to occur. During normal daily operation, there is adequate vehicle headway to allow the merge-down to cope with demand, however flow breakdown occurs during the course of weekly peaks (typically Friday PM and Saturday) and during exceptional events (typically bank holiday periods). In periods of excessive demand, the queue formed at the merge down would routinely stretch the mile back to the roundabout, then stretch back to around a mile (during weekly events) or two to three miles (during exceptional events) before the junction. Because there was no control over traffic entering the roundabout, westbound traffic would continue to enter, effectively blocking the local cross traffic movement on the A345 Countess Road, due to the consequential grid-locking of the roundabout. This in-turn would lead to traffic congestion occurring in the surrounding road network, causing severe delays in the centre of Amesbury (located 1 mile south of the junction).

The eastbound approach – view before the scheme

2. Scheme Design

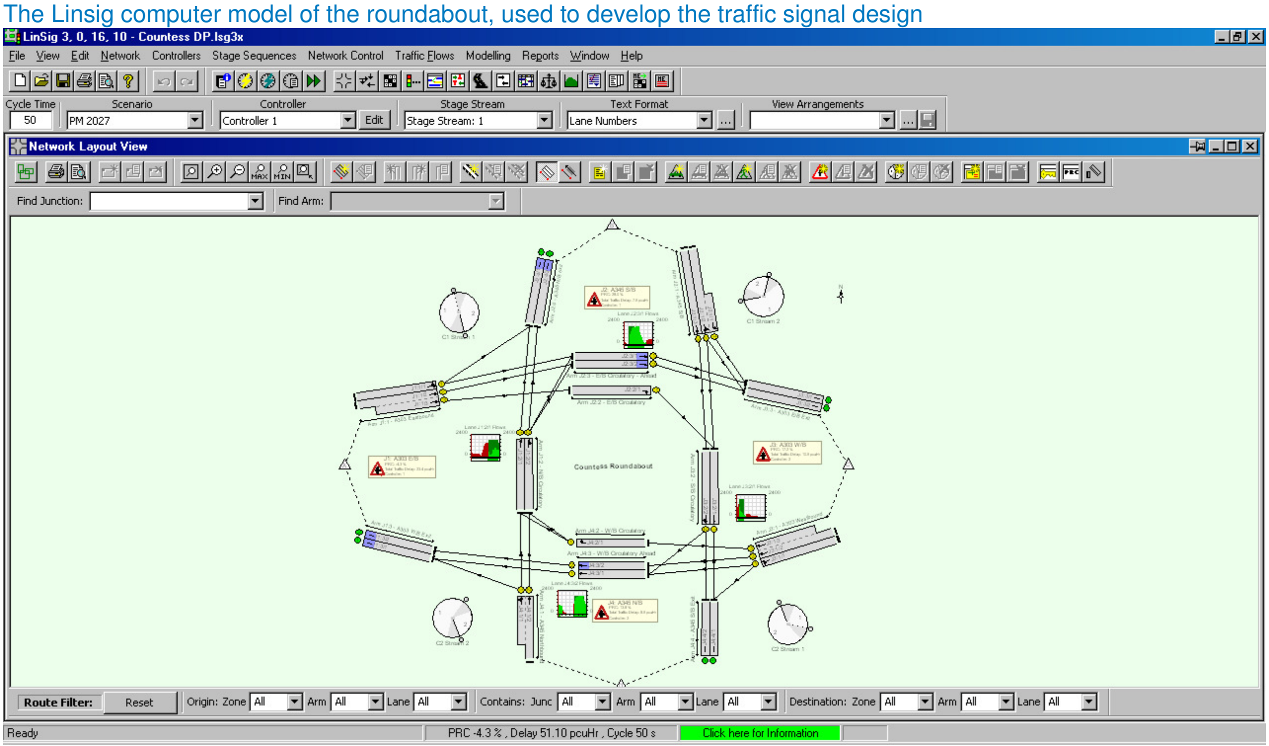


The design of the scheme would need to not only account for the safety issues identified with the junction, but also the congestion caused by the exit blocking on the westbound carriageway. In addition, it would need to seriously consider the requirements of the sensitive environment and the implications of the adjacent Stonehenge World Heritage site.

The work at the Countess Roundabout was undertaken to improve safety by signalising the existing roundabout. The scope of the works allowed for other improvements, such as the local widening of the A303 and the roundabout to three lanes. In addition, two other separate schemes had been authorised for the junction, to carry out works to the street lighting and to pavement / drainage. It was quickly identified that benefits could be achieved by combining the three separate schemes so that they were carried out at the same time.

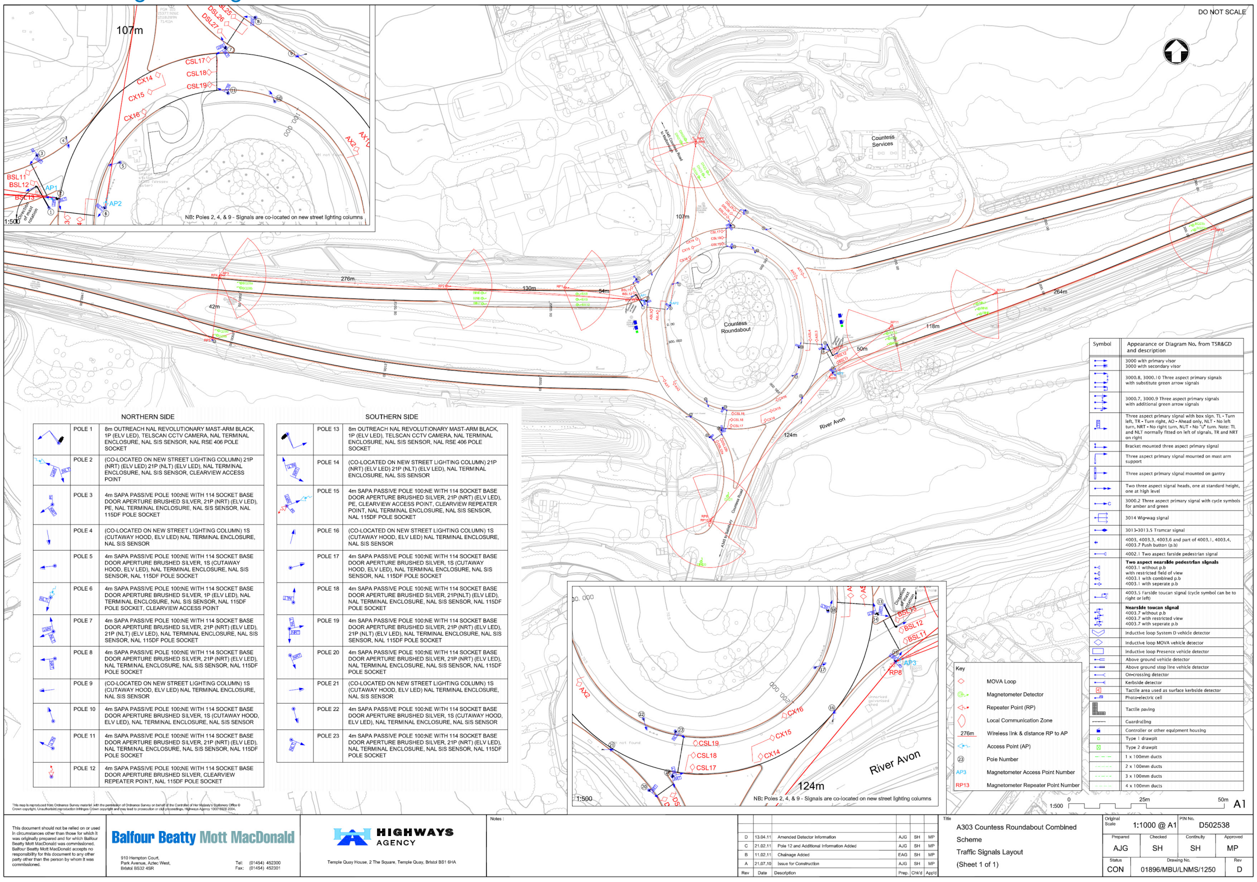
2.1 Signal Design

The Linsig computer model of the roundabout, used to develop the traffic signal design



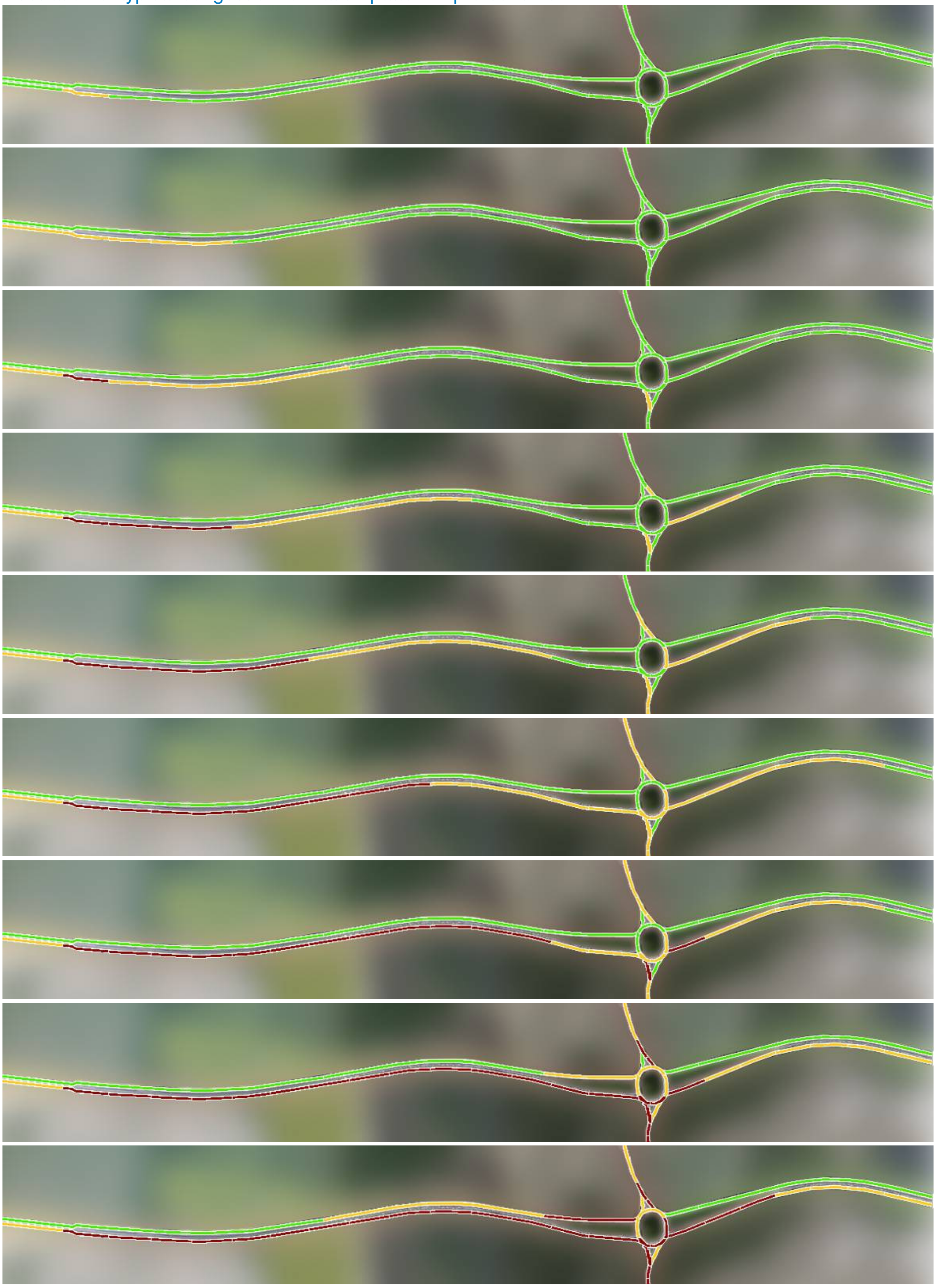
The signal design for the scheme not only had to account for the predicted traffic growth to 2024, but also had to allow for a heavy increase in HGV traffic which could emanate from the proposed development of a number of distribution centres along the A303 corridor. The junction was modelled in Linsig, which confirmed that extra localised capacity would be required to meet the forecast traffic volumes. This revealed that the A303 approaches should be locally widened to three lanes on the approaches to the roundabout, but that the extra capacity on the circulatory carriageway would only be required for the east/west-bound traffic. It was decided therefore, that alterations to the geometric design of the roundabout would be made to tackle not only the capacity issues, but also to optimise the design from a safety perspective. Although the lack of horizontal deflection had been identified as a major contributing factor to the accident rate at the site, this would not be altered because the existing alignment would actually meet the requirements for a signalised approach more closely as it was, allowing clearer inter-visibility between the conflicting traffic movements.

The traffic signal design for the roundabout



A key feature of the design was to include provision to deal with the exit-blocking which occurs on the westbound carriageway. The egress copes with the normal flow profile, however during periods of increased demand, typically on Friday afternoons and Saturday mornings in the spring and summer, the increased demand results in congestion occurring a mile downstream of the junction. The seed point for this is located at the end of the dual carriageway, where two lanes reduce down to one on the subsequent single carriageway section. Before the scheme was built, the congestion during these periods would routinely reach back as far as the Countess Roundabout. When this occurred, traffic on the northbound A345 Countess Rd was immediately affected, causing disruption in the adjacent town of Amesbury. The approaching westbound A303 traffic also quickly became congested, and the operation of the rest of the roundabout was soon compromised by the congestion which then occured on the circulatory carriageway. Because the cause of the congestion was outside of the scope of the scheme, but was likely to remain an issue for the foreseeable future, it was decided that the best solution would be to include congestion detection on the affected westbound egress. This would mitigate the effects of the congestion on the operation of the roundabout by implementing queue relocation to the westbound approach of the junction, in order to keep the roundabout clear.

Illustration of typical congestion formation pattern – pre-scheme



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Source: Traffic data from site observations

Being an isolated trunk road site, the method of control selected for the day to day operation of the roundabout was MOVA, running on two traffic signal controllers, split north and south of the junction. In order to minimise operational issues caused by the relatively small stacking space available for the high volume of traffic on the circulatory carriageway for the west/eastbound movement, a decision was made to operate each of these as single streams for the respective A303 and A345 approaches. The two controllers are linked to ensure MOVA on both halves work in co-ordination.

2.2 Passive Safety

Even though the finished scheme would incorporate a 40mph speed limit in the vicinity of the roundabout, the need to implement the signal design in compliance with the Passive Safety requirements specified in *BS EN 12767*, is confirmed in Table NA1 of the national annex. This specifies that traffic signal poles (in an area with ≤ 40 mph speed limit) should ideally have a rating of 70:HE:1-3, although due to products not being available to meet this criteria, allows for poles with ratings as low as 100:NE:1-3 to be substituted. Because the site is located directly on the mainline carriageway of the A303, it was decided that there could be a high incidence of drivers who would not adhere to the new posted speed limit, and that the scheme elements should be designed to take this into account. In addition, the presence of pedestrians and cyclists in the immediate vicinity of the signals is greatly reduced by the existing provision of a well used pedestrian underpass under the entire site. The standards adopted therefore, for safety restraint systems and road side structures bore this in mind, which resulted in the use of products with a 100:NE:1-3 rating being far more appropriate for the signal design. The poles specified for the scheme met this rating, and in accordance with the Area 2 requirements for signal designs, were specified to be installed in retention sockets, making reinstatements easier and quicker in the event of a knockdown occurring. Because of both the safety and potential energy saving benefits of extra-low voltage (ELV) traffic signal equipment, the design utilised this type of equipment, but still required the use of a isolation system for the poles. Because the poles specified are designed to yield in the event of an impact (rather than failing/shearing), the most appropriate means of achieving the electrical isolation would be to use a system which uses an inertia switch located in each pole to trigger circuit breakers, rather than using snatch plugs. The combination of the relatively light mass of the poles and heads, allied with the use of ELV electrics and the safety isolation system were felt to offer the safest system combination, not only to occupants of errant vehicles, but also for maintenance staff as well. The only parts of the design which are not passively safe were the proposed mast-arms and the traffic signal controller cabinets. It was felt that the contribution made to the design, by the rotating mast-arms, by increasing signal visibility and removing the need to carry out maintenance operations from the mainline carriageway, made their inclusion worthy. Because of the immediate vicinity of the pedestrian underpass, to the westbound approach, a safety fence was required to protect it. By placing the very substantial mast arm along with the traffic signal controller cabinets behind this, easily achieved protection for these. A similar layout was included in the design on the eastbound approach to protect the mast-arm and cabinet locations behind a safety fence. A risk assessment process was undertaken to ensure that the equipment selection criteria used in the scheme was verified and recorded, allowing future reference to be made if needed. The current EuroRAP assessment for this section of the A303 is scored as a "*Low – Medium Risk Road*", and to ensure that subsequent appraisals correctly recognise the characteristics of the new traffic signal infrastructure included in the scheme, each post and column is specified to be fitted with a colour coded retro-reflective band. Traditional non-passive structures have a white band fitted in compliance with Clause 3.7 of *TR102A*, at approximately 1.5m above ground level, but the passively safe poles are differentiated by a green band.

2.3 Shared Facilities

Because the scheme encompassed other elements such as street lighting, it was decided to take advantage of the opportunities this would provide for rationalisation, by sharing any elements where possible. This was undertaken to improve the overall safety by minimising road side clutter and to offer a cost benefit. The traffic signal designer worked closely with the street lighting team in particular to co-ordinate the two specialism's designs, which resulted in the identification of two aspects that could be shared:

- **The duct network** – Both specialism's were using a fully ducted network, which was largely located in similar positions.
- **Column's** - Six locations were identified where traffic signals would be located in close proximity to lighting columns.

It was decided to investigate the possibility to co-locate these facilities. The duct network was designed to use common draw pits, but to use segregated ducts to separate the cabling. The design of a lighting column which could co-locate both street lighting and traffic signals was investigated, and a suitable manufacturer identified. It was decided that the shared columns would be equipped with two door apertures in order to allow the two sets of cable terminations to be separated. The doors are clearly marked externally for "traffic signals" and "street lighting" respectively. Since the columns are passively safe, and are designed to yield in the event of a vehicle strike, both systems would be fitted with electrical isolation systems which are activated by inertia switches. Because of the difference in the electrical potentials (the street lighting uses mains (I.E. 240v LV) compared with the traffic signals which are extra-low voltage (I.E. 48V ELV)), the isolation systems have been kept separate from each other. The traffic signal isolation equipment is housed in miscellaneous equipment cabinets adjacent to each traffic signal controller, whilst the street lighting system uses individual enclosures located in the adjacent draw pit.

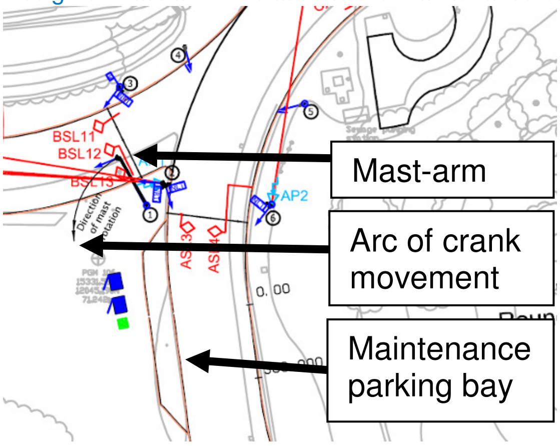
Separate doors on shared columns

View of two of the shared columns

2.4 Equipment

In order to maximise forward visibility of the traffic signals on the A303 mainline carriageway approaches, it was decided that supplementary high-level signals would be necessary. This was particularly necessitated because of the lane flare on the final approach, which results in three lanes for the last 100m. Because of the high incidence of HGV's on the route, and the anticipated level of these undertaking right-turn movements at the junction, it was felt that it would be common for other drivers to be affected by the "canyon effect", where the presence of tall vehicles in lanes 1 and 3 could obscure the view of the traffic signals to following drivers. This has been overcome on other schemes by using a 6m pole with a supplementary high level repeater for the off-side duplicate primary, however this can lead to access issues requiring road-space for maintenance, and does not totally solve the visibility issues. It was therefore decided to look at a new mast-arm design, which offers the normal benefits of placing the additional signal head over the centre of the carriageway, whilst also overcoming the normal access issues for maintenance. The new style of mast-arm is equipped with a rotating outreach, which allows the arm to be cranked round over the verge when work is needed. The scheme design was therefore undertaken to include a maintenance parking bay on the central reserve, on the near-side of the circulatory carriageway. Because of the geometry of the existing roundabout, the central reserve of the A303 at the roundabout is more than big enough to accommodate this. By implementing this feature, it allowed the design to cater for parking a mobile elevated work platform (MEWP or "cherry picker") in the maintenance bay, and by cranking the arm round, to access it for maintenance without the need to deploy traffic management. The mast-arms are equipped with electrical isolators, which allows the signal head on it to be extinguished, prior to maintenance activities being carried out.

Design of mast-arm in relation to the maintenance bay



Mast-arm being accessed from MEWP

The location of the maintenance parking bays also gave the opportunity to position the equipment cabinets adjacent to them, so that they would be easily accessible for engineering staff.

Previous experience of the occasional poor civil's installation of retention sockets led to the development of a design to include a concrete surround in soft-verges, so that the extent of the surrounding concrete foundation is brought up to surface level. This adds the advantage of ensuring the integrity of the foundation, whilst at the same time offering a clear working area, clear of vegetation. It was decided that the use of a concrete pad around the area of the controller cabinets would also be advantageous. By pouring a large slab around the entirety of the cabinets, electrical feeder pillar, draw pits and the earth point, it was felt that it would make the finished installation tidier and easier to work at in the future. The draw-pits located in front of each cabinet are set back a metre to allow engineers to work at the cabinet if the pit lids are open. The use of this type of concrete pad was also specified for the remaining isolated ducting system draw pits, to allow the lids to be lifted easily.

Cabinet hard-standing next to the maintenance bay

Examples of pole and pit surrounds

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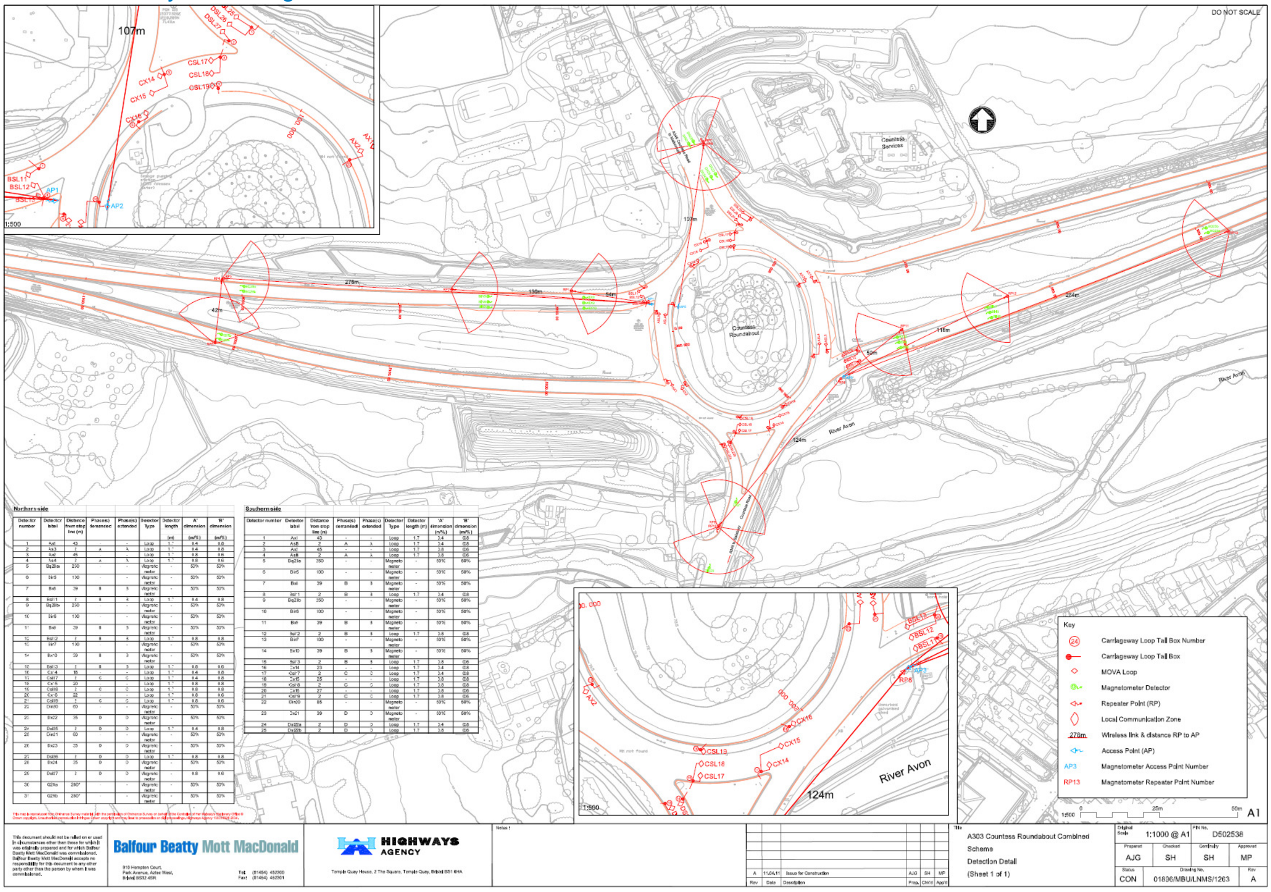
2.5 Vehicle Detection System

The envisaged functionality of the signals would require a comprehensive vehicle detection system, with a number of detectors required at extended distances from the controllers. It was decided that inductive loops would be used on and around the roundabout, but because of the requirement to detect vehicles at locations which exceed the recommended maximum length of loop feeder cables and the necessity to place detection beyond an adjacent river bridge, possible alternative detection technologies were investigated. On the main line carriageway, the MOVA queue detectors were specified to be at 250m from the stop-line and there was also a need to place congestion detectors over 200m downstream of the roundabout on the westbound egress. Because of the long cable runs, these situations would necessitate the use of remote detector cabinets and extended duct runs, if implemented with inductive loops. In addition, the A345 Countess Road on the southern arm of the junction, passes over two immediately adjacent bridges spanning the River Avon. These are constructed with shallow bridge decks, and are the property of the local authority, Wiltshire County Council. It would therefore be problematic to be able to install ducts across these.

The detection system design



To overcome this, the use of magnetometer detectors which utilise a wireless communications facility back to the traffic signal controllers was investigated. Because of the essential nature of this element to the effective operation of the completed installation, it was decided that a due diligence investigation should be undertaken, because the technology had not been previously used on a trunk road site at the time when the design was being undertaken. The investigation successfully answered concerns over reliability of a wireless deployment, battery life expectancy and accuracy of detection. In collaboration with the equipment supplier, the design was developed to use the technology on the four approach arms beyond the stop-line locations. This provided economies on the length of the required ducting system and negating the need to use any remote detector housing cabinets.

The completed scheme included a fully revised signing and lining strategy as an integral part of the new design

3. Construction

Despite the scale of the scheme, the construction phase went particularly well. To assist this, the signal designer was regularly on site to liaise with the site staff and contractors. This ensured queries and issues were dealt with promptly and without ambiguity, resulting in a high quality installation being achieved.

In addition to the normal traffic signal construction and installation issues involved with scheme deliveries, the use of new technologies and the scale of the site work, such as the complete reconstruction of the carriageways, the new drainage system and the build of the new roof slab for the pedestrian underpass, posed additional issues to the successful delivery of the project. Some of these issues are examined below.

3.1 Mast-arms

The foundations for the two mast-arms are 2m square by 1.8m deep, ferrous reinforced concrete, with a mounting cradle, cast in-situ. These were constructed and allowed to cure before the rest of the installation was carried out. Each mast-arm was erected in two parts, with the column lifted into place by a *Hiab* on the delivery lorry. The column was bolted down to the mounting cradle in the foundation, after which the outreach was lifted and fixed into place on top of it. The traffic signal head had been pre-mounted onto the outreach whilst it was still on the ground, and the cable fed through the arm and column before the assembly was completed. After all the fixings had been checked, the rotating mechanism was tested. The installation process for the mast-arms was exceedingly straightforward, and both were erected in a single morning. Because of the way that the system allows the outreach to rotate, it offers the additional benefit of not requiring road-space on the mainline approaches during the erection process.

Mast-arm foundation – concrete pour

The outreach being lowered onto the column

3.2 Ducts over underpass

During the construction of the scheme, an issue was identified with the routing of a number of ducts across the top of the pedestrian underpass. Although the initial trial holes had indicated that there would be sufficient cover in the soft verge over the top of the roof slab, it was found that additional works to the structure meant that it would not be possible to run 100mm ducts in the affected location. To overcome this, 50mm diameter galvanised steel ducts were used, and by increasing the number, it was possible to meet the capacity requirement for this section of the duct network. The steel ducts were then encased in a poured concrete slab, to protect them from damage.

50mm diameter steel ducts, before concrete pour

3.3 Wireless magnetometers

Because this was the first scheme that the signal designer had specified the use of this type of detection (although subsequently designed projects had reached construction before this scheme), a close liaison with the manufacturer was kept, in an attempt to minimise any potential issues. The installation of the magnetometers themselves was exceedingly straightforward; each unit was fitted in a matter of a few minutes. The installers used a large core drill, powered by a petrol engine, to accurately cut the hole into which the detectors were fitted. These were then sealed into place using a two part epoxy resin.

Core drilling

Magnetometer placed in hole

Unit sealed in place with epoxy resin

Although these units were installed whilst the sections of road were closed, it proved that they can be fitted in a much quicker time than a traditional inductive loop, and that because they are positioned in the centre of a lane, the necessary area needed to install them is dramatically reduced. This could be highly beneficial in situations where available road-space is at a premium.

3.4 Shared duct system

The use of the ducting system, which are shared by both traffic signals and street lighting worked well, and provided a substantial cost benefit. With dramatically fewer draw pits than would be otherwise required, the rationalisation also allowed a large proportion of the chambers to be increased in size. This made cable pulling far easier, and allowed plenty of room for inductive loop bottle joints and the street lighting safety isolation units to be securely fitted to the chamber walls. The only issue posed by the shared system was during the specialist installation phase, when both street lighting and traffic signal installers were on site at the same time. However, the impact of this was minimised by careful job phasing and co-operative working by the different contractors.

Circulatory carriageway, part way through the plaining out process

4. Findings

The traffic signal installation underwent a thorough commissioning, where each sub-system was individually pre-tested before the whole installation was system tested. Once operational, a validation process was undertaken immediately, in order to optimise the operation of MOVA and the congestion management plan.

This process ensured that the system was operating under MOVA control from the first day the site was switched on. By doing this, the scheme offered the most efficient method of control from the start.

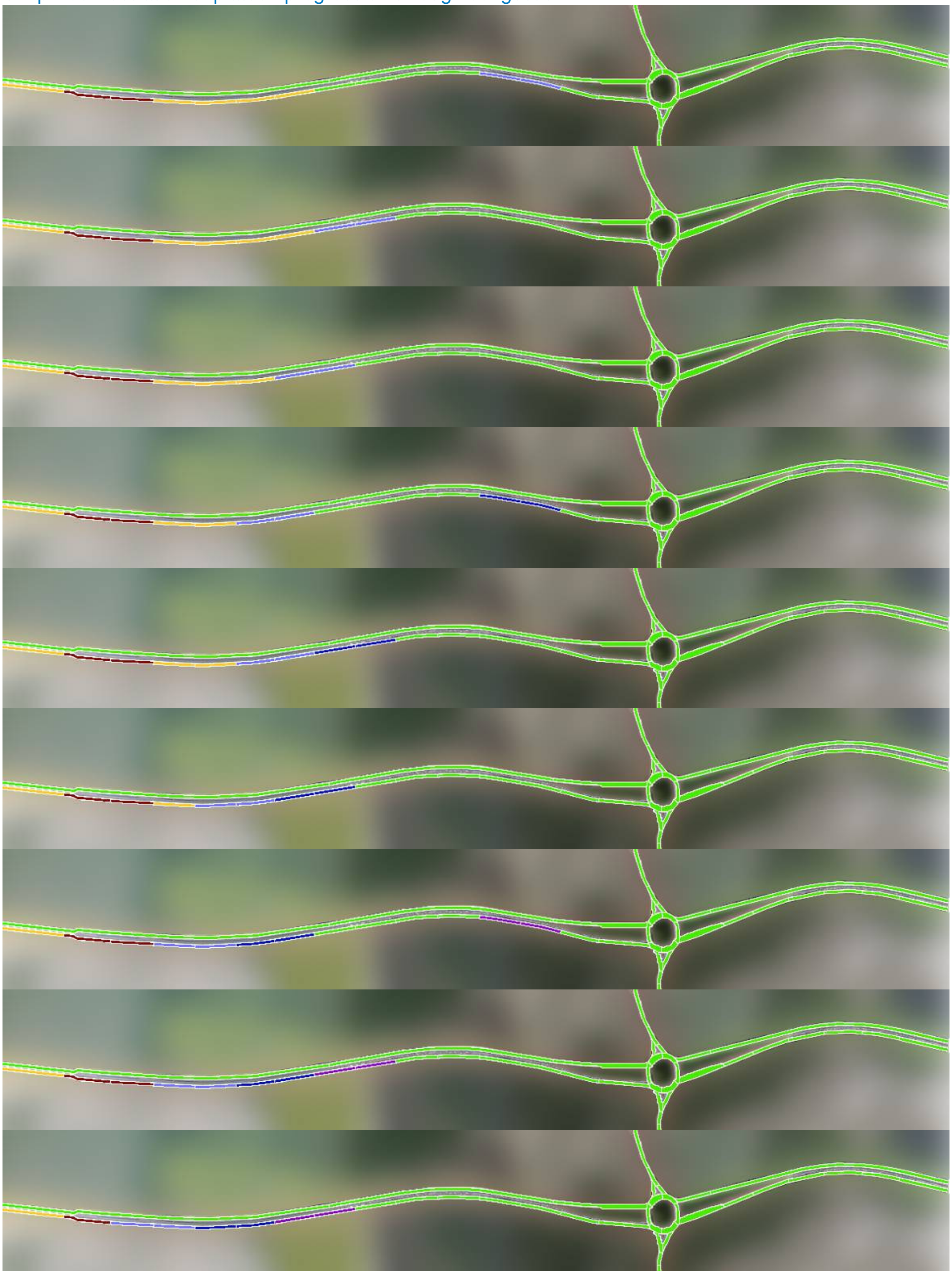
Commissioning in progress

4.1 MOVA Operation

The traffic signals were found to operate exceedingly well under normal traffic conditions. Before the roundabout was improved, it was normal for the site to routinely suffer queues on the approaches. However, once the new traffic signals were switched on, these disappeared almost immediately. The site agent was so impressed that he asked "*Where's all the traffic gone?*".

However, under heavier volumes of traffic, an interesting effect was observed on the westbound traffic downstream of the roundabout. Before the roundabout was signalised, once the traffic exceeded a threshold, a queue would form at the merge down point at the end of the dual carriageway. Because of the dispersed but constant nature of the traffic arriving at this bottleneck, the queue length would build following the characteristics of the shockwave effect, and could propagate in length to stretch back over the mile distance to the upstream roundabout, in as little as 5 minutes.

Simplified illustration of platoon progression through congestion



Existing congestion at merge down, platoon (No. 1) approaching.

New platoon joins end of existing queue

Queue dissipates

Queue continues to dissipate, next platoon (No. 2) approaches

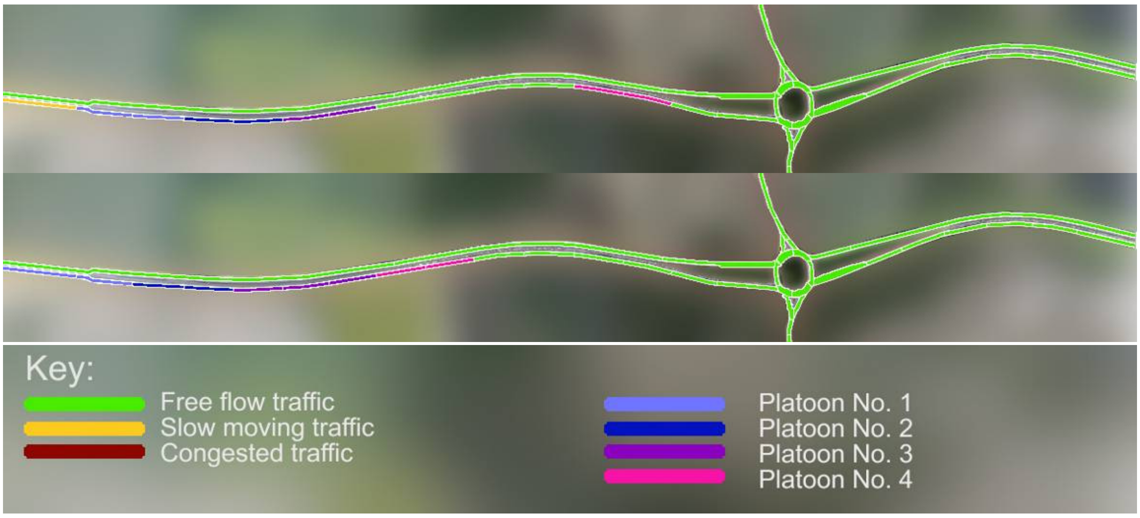
New platoon joins end of queue

Queue dissipates

Queue continues to dissipate, next platoon (No. 3) approaches

New platoon joins end of queue

Queue dissipates



Queue continues to dissipate, next platoon (No. 4) approaches

New platoon joins end of queue. Initial observed platoon (No. 1) starts to pass merge-down point.

After the signals were operational (under similar traffic flow conditions), although the queue would still form at the bottleneck, the effect of the traffic being split up into compressed platoons by the traffic signals, would result in the queue length oscillating. As a platoon reached the back of the queue, the overall length would grow, but between arrivals would dissipate. Site observations over the course of a number of visits found that the resulting queue length was constrained in all but exceptional traffic conditions. The diagrammatic representation above illustrates the queue length oscillation and the progression of individual traffic platoons through the congestion. In addition, previously the queue would be maintained after its establishment, by even a modest volume of traffic, and would only disappear when the incoming traffic reduced to almost nothing. With the signals operating however, the queue has been observed to completely dissipate on occasions.

The traffic signal controllers are programmed so that they revert to the All-Red stage, when there is no demand from vehicles on any of the approaches. This typically only occurs during off-peak periods, when the speed of vehicles approaching the junction tends to be higher. This has the tendency to improve safety by constraining approaching vehicle speeds, during periods when lone vehicle accidents caused by excessive speed are a more common phenomenon. This facility also means that vehicles are less likely to be delayed at the signals during these periods, by allowing the movement to the relevant approach to occur without a delay caused by waiting for an opposing minimum green or a long inter-green period to expire.

4.2 Congestion Management

The route suffers from exceptional traffic flow events, typically during the spring and summer (particularly before bank holiday weekends), when large numbers of holiday makers set off for the West Country. During these periods, the congestion caused by the down stream bottleneck used to reach back through the roundabout and stretch back upstream a further 2-3 miles. To mitigate the effect this has on the operation of the roundabout, the new traffic signals incorporate a Congestion Management feature. Queue detection equipment is located over 200m downstream of the roundabout on the westbound movement, which is used to trigger an emergency CLF plan in the event of congestion being detected. The plan controls the operation of the traffic signals on the eastern-side of the junction, which controls the westbound movement. The controller on the other side of the site continues to operate under MOVA, therefore optimising the traffic throughput on the eastbound movement. Once initiated, the plan operates for a fixed period of 5 minutes, with subsequent 5 minute periods being applied, until the queue has dispersed. This results in a queue relocation for westbound traffic, by holding this traffic movement back, and placing it upstream of the signals on the westbound approach. By implementing this strategy, the roundabout remains operational (and not gridlocked as it used to be in these circumstances). The initial indications show that the overall journey time through this section of the route is reduced, even under these more extreme circumstances.

Initial testing of the facility was successful, although the operation of the signals had to be modified at the "end of event" point. It was found that when the volume of traffic fell, and the queue detection was no longer indicating a queue, the traffic signal controller would go back to operate under MOVA. However, because MOVA is so efficient and flexible, it would detect a queue on the mainline approach, and routinely give this approach an extended duration, as it attempted the clear it. The result of two cycles of the signals, where it would apply green times of a minute or so, to flush through the waiting traffic, would often effectively clear the upstream congestion on the approach. However, it achieved this at the expense of over-saturating the downstream traffic, and result in the re-introduction of the emergency CLF plan. This was observed to cycle through this process on several occasions until the inbound traffic volume fell below the critical threshold level. To overcome this, and not to constrain the normal operational capability of MOVA, the traffic signal controller configuration was amended to operate under the local method of control (either VA or CLF, under timetable selection) for a further 5 minutes, after the end of the emergency plan. This was done in order to constrain the volume of traffic throughput in an attempt to allow the downstream queue to dissipate further, before re-introducing MOVA. In use, this was found to offer a more effective "end of event" switching back to MOVA, and reduced the instances of almost immediate resumption of the congestion management emergency plan operation.

During periods whilst the emergency plan is operational, it has been found to be highly effective in keeping the roundabout operational. This has been greatly appreciated by local drivers who use the cross junction route, which had previously been adversely affected by the grid locking caused by mainline traffic swamping the junction. The chair of the local chamber of commerce said "*I take my hat off to you, I never thought it would work!*". The only problem that has been experienced with the congestion management facility has stemmed from the occasional driver on the mainline approach, becoming frustrated and continuing to drive across the stop-line after the end of the green period.

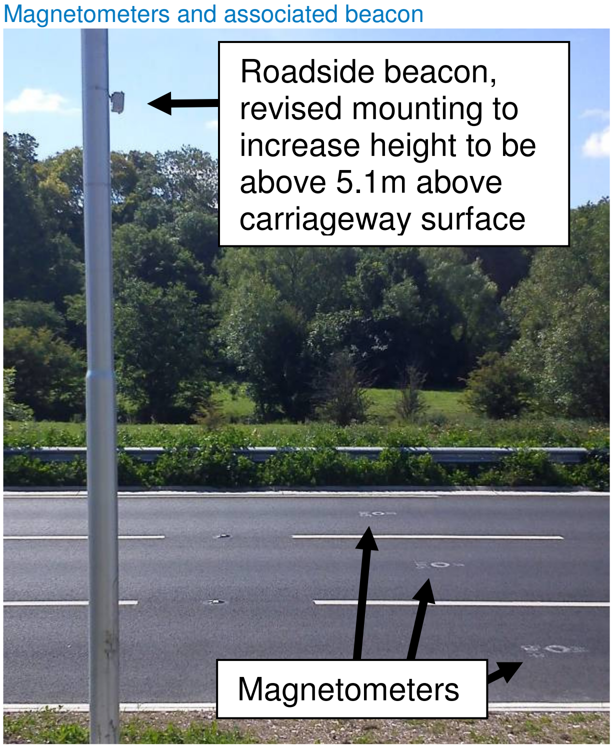
4.3 Wireless Detection

The scheme utilises a wireless vehicle detection system on the approaches in order to minimise the extent of the ducting system and the necessity for additional cabinets to house remote inductive loop detector racks. Although the system was found to operate successfully, it was noticed that some of the detection outputs from the sub-system were not as crisp as expected and that occasional pulses seemed to stay active for much longer than necessary.

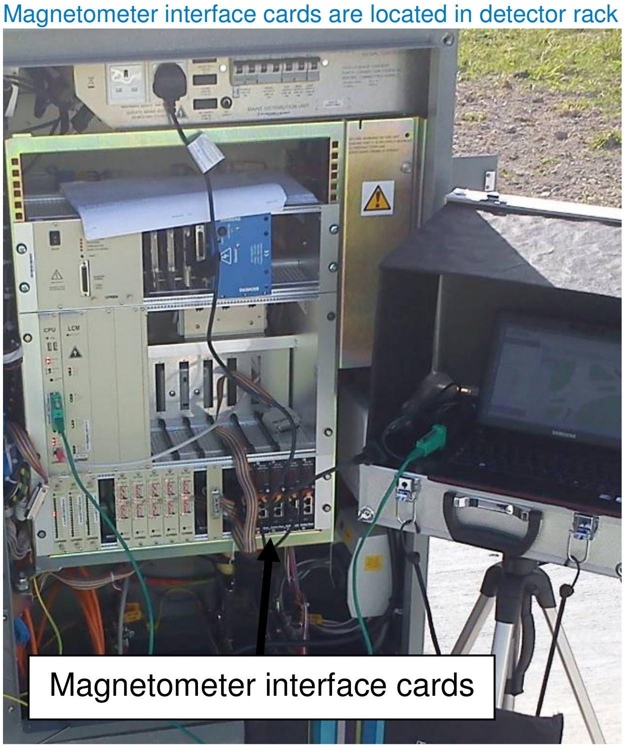
Investigation revealed that the radio communication between the roadside beacons could be interrupted by passing HGV's, which although all data would eventually be passed to the signal controller, could result in it not being as precise as required to operate an exacting real-time method of control, such as MOVA. The phenomenon posed a particularly problematic issue to the operation of the congestion management system on the site, which relies on the use of call / cancel detection to determine the presence of slow moving traffic. It was found that a passing HGV on an equipped lane, could start a detection pulse, but would then interrupt the radio link back to the traffic signal controller, due to its own trailer height masking the line-of-sight link between the beacons. This would result in the detection pulse at the traffic signal controller being generated, but then held until a subsequent vehicle passed over the affected detector, which would then reset the affected channel of detection. The sluggish nature of the system adversely affected the efficient operation of MOVA and the extended pulses were responsible for the congestion management emergency plans being initiated unnecessarily.

The issue was overcome by remounting the roadside beacons higher off the ground, so that they were a minimum of 5.1m above the carriageway surface. This ensured that they are above the top of passing tall vehicles, resulting in a reliable signal being maintained between the different parts of the system. This was easily achieved in most locations, because most of the units were banded to street lighting columns. However, for the queue detector positions on the A303 approaches, these had been mounted on the advance destination sign poles, which were not tall enough to achieve the 5.1m height requirement. This was overcome by mounting a “ghost” pole on the rear of the sign plate, and fitting the beacons to these. The operation of this part of the detection system is now indistinguishable from the inductive loops.

Magnetometers and associated beacon



Magnetometer interface cards are located in detector rack



4.4 Communications

Both traffic signal controllers are equipped with an array of communications facilities, including a Wifi access point, which allows the controllers to be interrogated on site from a laptop, without the necessity to have the cabinet door open. The two controllers are also linked by an RS485 link, which is particularly useful during MOVA validation, because it allows both traffic signal controllers to be monitored simultaneously from one controller location.

Because the traffic signal controllers include a web-server to disseminate information, the use of handset mnemonics is minimised by the use of forms which allow settings to be altered and a range of facilities monitored in real-time, including a mimic display of the controller operation displaying phase, UTC and input/output information. It also opens the possibility to run two communications channels to the controller equipment at the same time, by using a web-based page via a Wifi link, along with a traditional terminal emulator directly via the engineer's handset port.

CCTV Image

Controller mimic display

In addition to the traffic signal controller, the Outstation Monitoring Unit (separate from the MOVA unit for compatibility with the Remote Monitoring System (RMS)), the MOVA unit and the low-cost CCTV system are also equipped with Ethernet connections, which allows remote communications to be carried out via a broadband telephone connection, by assigning each sub-system with a unique IP address.

By using the range of remote communications facilities included in the installation, it is possible to not only monitor faults automatically with the fault management system via RMS, but also the operation of the signals and MOVA, and to view and control the CCTV system.

4.5 Hard-standings

The concrete surrounds to the cabinets, poles and draw pits were found to be highly successful. The design had incorporated a brushed surface texture which was found to offer an effective non-slip surface when wet. The slabs around the cabinets provide a clear working area, which was exceedingly useful during the equipment installation and the commissioning and validation process. The draw pit surrounds also mean that engineers have a good footing when lifting lids, and that there is somewhere to kneel on when working in them. The pole surrounds provide a good quality foundation for the retention sockets, which is particularly important in the event of a vehicle striking a pole. One possible development with the design of these for subsequent schemes, may be to elongate one side of the pole slab, to allow maintenance engineers' 'A-frames' to be sited on a secure level surface.

5. Conclusions

Although the scheme is now fully operational, it is still too early to provide data on the effectiveness of the safety improvements. However, site observations of the newly signalised roundabout have shown that the junction is functioning well, and its improved operation has received a great deal of praise.

The primary improvements are in the safety and efficiency of the roundabout operation, but in addition the environmental enhancements and careful design of the facilities will continue to benefit the junction for many years to come.

5.1 Safety

The primary reason for undertaking this scheme was to provide safety improvements to the junction, in order to reduce the accident rate. At the time of writing this paper it is too early to provide updated accident statistics, although early indications show that a major improvement has been achieved.

5.2 Efficiency

The efficiency of the roundabout operation has been greatly improved by the scheme. The operation of the junction can be characterised by four scenarios, all of which offer demonstrable improvements:

- **Low** traffic volume – The inherent flexibility of the MOVA method of control, and the way in which the controllers are programmed so that the quiescent state is the All Red stage (in the event of no demand being present from vehicles on any of the approaches), promotes the safe but efficient transit of vehicles through the junction.
- **Normal** traffic volume – The MOVA method of control offers a highly efficient means of controlling traffic, whilst operating under a queue dispersal regime.
- **Congested** traffic volume – MOVA continues to offer the most efficient means of control by changing to a capacity maximising optimisation. The presence of the traffic signals also benefits the downstream exit blocking issue, by splitting the traffic into platoons, which dramatically reduces the incidence of over-saturating the bottleneck, at the merge down point at the end of the dual carriageway.
- **Exceptional** traffic volume – During periods of very high traffic demand, the down stream exit blocking constrains the ability of the roundabout to operate. Congestion detection monitoring the westbound egress is used to automatically initiate the operation of The Congestion Management Plan. The traffic signals ensure that the roundabout does not become grid-locked, by implementing a queue relocation to the westbound approach. This not only allows cross traffic to keep flowing, and hence the neighbouring local road network, but would appear to reduce the overall journey time through this section of the A303 in these conditions.

5.3 Environmental

The aesthetics of the installation and the improved efficiency to traffic movements are likely to be highly beneficial to the surrounding sensitive environment and the neighbouring Stonehenge World Heritage site.