TRANSPORT RESEARCH LABORATORY

Roundabouts in continental Europe designed with cycle facilities or ‘cycle-thinking’

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Executive Summary

Although roundabouts in Great Britain have been designed primarily to maximise junction traffic capacity, research has shown that converting give-way junctions to roundabouts, with off-side priority, does reduce accident numbers for four-wheeled vehicles. However, the number of accidents involving two-wheeled vehicles hardly changes and this has led to a situation where there seems to be a disproportionally high number of cycle accidents at roundabouts.

In other countries of Europe the installation of roundabouts was rare until after the mid 1960s when British research showing the benefits of roundabouts operating under the off-side priority rule became widely known. Since that period a number of countries have undertaken research and development into roundabout design and safety. In localities where there are high levels of cycle traffic there have been experiments to develop roundabouts with facilities specifically for cyclists, or with modifications intended to help cyclists. The full report describes a study tour undertaken to review such developments in Denmark, Germany and the Netherlands.

Research in various European countries, as well as in Britain, has found that roundabout junctions operating under the off-side priority rule have a higher traffic capacity and fewer injury accidents than uncontrolled or give-way junctions. However, the predominant residual accident type at such roundabouts is a cycle accident where a circulating cyclist is struck by a motor vehicle entering or leaving the circulation. Ways to reduce the number of cycle accidents at roundabouts are being sought in almost all European countries, not least because of national policies to promote cycling as a sustainable and health-improving means of transport.

In pursuit of greater cyclist safety, traffic engineers in Denmark, Germany and the Netherlands have moved from British roundabout designs with flared entries and wide circulation to a tighter geometry of radial entries and narrow circulation. In Germany and the Netherlands the newer designs do seem to have reduced vehicle speeds and researchers in the Netherlands have observed reductions in the number of cycle accidents. The Danish roundabouts visited were not as tight as the roundabouts visited in the other two countries and motor vehicle speeds were higher. It was not surprising, therefore, that research in Denmark should show no significant reduction in cycle accident numbers after the roundabouts were installed.

At the German roundabout visited and at some of the Dutch roundabouts cyclists circulating on a separate peripheral cycle track or segregated lane had priority over vehicles which were either entering or leaving the circulation. At the roundabouts observed this arrangement was working very well: the vehicles were stopping and the cyclists seemed confident that they would stop. Nevertheless, Dutch research shows some residual cycle accidents where vehicles have not given way and these roundabouts with cyclist priority are considered significantly less safe than roundabouts where cyclists on a separate track or lane give way.

There is a need for further research on British roundabouts:

- to investigate how vehicle speeds through roundabouts can be reduced;
- to discover what effect vehicle speed reductions have on cycle accidents; and
- to find how the speed changes affect the traffic capacity of the roundabout.

At the same time developments in other European countries should be monitored closely:

- to evaluate the relative benefits of separate cycle tracks, cycle lanes and cyclists on the circulation; and
- to determine the best priority rule for cyclists on tracks and segregated lanes.

1 Background

Roundabouts are a fairly common junction type within Great Britain: their development can be traced back at least to the nineteenth century (Todd, 1989). In the early 1960s the roundabout was modelled as a set of T-junctions connected by 'weaving lengths', wide one-way carriageways where traffic could weave to overtake entering and leaving vehicles. At this time there was no priority rule and the traffic capacity of the roundabout was thought to be dependent on the width and length of the weaving sections (Road Research Laboratory, 1965). Research at TRL (then the Road Research Laboratory) found that the capacity of roundabouts was increased if traffic entering the roundabout gave way to traffic on the roundabout, ie if offside traffic had priority (Blackmore, 1963). This rule not only increased capacity but had the additional benefit of preventing roundabout gridlock, which had become a serious problem at the most heavily used roundabouts. There was no evidence that the use of the offside priority rule made roundabout accidents more likely than they had been and in 1966 offside priority at roundabouts was officially adopted throughout the United Kingdom.

Further research by Blackmore and his colleagues at TRL led to the development of smaller roundabouts including the mini-roundabout, a junction with a painted central island, indicating the operation of the offside priority rule, but virtually no circulation lane.

Up to the 1980s roundabout design was directed primarily towards increasing traffic capacity. However, comparison of casualty numbers at junctions before and after conversion to a roundabout showed that accident numbers were less with the roundabout. Detailed research showed that the main reduction was the reduction in four-wheeled vehicle accidents and that the number of accidents involving two-wheeled vehicles hardly changed. This has led to the situation in Great Britain where there seems to be a significant and disproportionately high number of cycle accidents at roundabouts. Some perspective on cycle accidents at roundabouts may be gained from Table 1 below. Though cycle accidents are generally well dispersed over the rest of the road network, they tend to cluster at roundabouts. On built-up roads (speed limit of 40mph or lower), in 1996, 12% of all bicycles in accidents at junctions are involved at roundabouts, and on non built-up roads (speed limit above 40mph), the figure is 29%. (The Department of the Environment, Transport and the Regions et al, 1997).

Roundabouts are the junction type that cyclists most commonly try to avoid (Watkins, 1984). At roundabouts cyclists see themselves as at the mercy of motorists. The perception is correct: a very high proportion of cycle accidents at roundabouts, both conventional and mini, involve a circulating cyclist, who has priority, being hit by a motor vehicle entering the roundabout (Layfield and Maycock, 1986; Kennedy et al, 1998). Numerous investigations of such special facilities for cyclists as complete or partial cycle lanes on the circulating carriageway, peripheral cycle tracks and give-way crossings of the entry/exit arms, have failed to demonstrate any statistically significant reductions in cycle accident numbers at roundabouts. However, there is a statistically significant reduction in the severity of cyclist injuries at roundabouts compared with other forms of junction. The proportion of serious and fatal injuries at roundabouts reported by Layfield and Maycock in 1986, 15 per cent, had not changed significantly in 1994 despite an increase in the average severity of cycle accidents at all locations, from 22 per cent to 30 per cent.

There have been indications of savings in cyclist casualties at experimental sites where the vehicle entry conditions have been modified. At the Barley Mow roundabout, in Hersham, Surrey, there was an average of seven accidents per year during the period 1977 to 1981, 90 per cent of which involved two wheeled vehicles. To try to reduce the number of entering/circulating accidents the entries were re-aligned to increase the deflection of entering vehicles and slow them down. The new layout did not eliminate entry-circulating accidents but their frequency was reduced from 3.7 per year in the six years before the change to 1.8 per year in the four years following. This reduction is statistically significant. It is important to note that the modifications to the roundabout did not include any features specifically for cyclists.

The introduction of traffic signals at roundabouts has also been shown to have a safety benefit for cyclists. This was expected since the signals separate cyclists in time

Table 1 Number of bicycles involved in accidents by junction type (Department of the Environment, Transport and the Regions, 1997)

Road type	*Round'b't*	*T/stagg*	*Y*	*X-roads*	*Multiple*	*Slip rd*	*Other*	*Private*	*Not jctn*	*Total**
Number of bicycles involved in accidents										
Built-up roads	2103	9734	336	2457	298	99	604	1324	5778	22734
Non built-up & Mway	312	386	34	100	11	87	35	129	1222	2317
All roads	2415	10120	370	2557	309	186	639	1453	7000	25051
Percentage of all bicycles involved in accidents†										
Built-up roads	8	39	1	10	1	-	2	5	23	91
Non built-up & Mway	1	2	-	-	-	-	-	1	5	9
All roads	10	40	1	10	1	1	3	6	28	100

** Includes junction type unknown.*

† Because of rounding errors the percentages shown in the cells do not always sum to the marginal totals.

from the greatest hazard - the incoming drivers.

Roundabouts are not as common in mainland European countries as in Britain, which was the first country to adopt an offside priority rule at roundabout junctions and thus facilitate high traffic flows with fewer motor vehicle accidents than at uncontrolled cross-road junctions carrying the same traffic. The reports of the traffic capacity and safety of the British roundabouts have led to some reappraisal and since the 1970s a number of countries have been building roundabout junctions. In localities where there are high levels of cycle traffic there have been experiments with roundabouts with facilities specifically for cyclists, or with modifications intended to help cyclists. The study tour described in the following chapter, was undertaken to review developments in the Netherlands, Germany and Denmark.

2 Study tour of continental roundabouts

2.1 Itinerary

A selection of roundabouts in Continental Europe, where there are cycle facilities or where some consideration has been given to the needs of cyclists in the design, have been visited. These schemes were selected in the hope that they would provide some pointers for further developments in Great Britain. Roundabouts in the following places were inspected in May 1994:

The Netherlands:	Enschede Zwolle
Germany:	Bremen
Denmark:	Köbenhavn (and suburban area to north) Nakskov Odense

2.2 The Netherlands

In 1985 roundabout design in the Netherlands changed considerably (van Minnen, 1994). Before the changes the roundabout plan was similar to the plan for medium to large roundabouts in Britain with splayed entries that allowed vehicles to enter the roundabout almost at a tangent to the circulation which was usually two or more traffic lanes wide. However, contrary to the priority rule in Britain, traffic entering the roundabout had priority over traffic on the circulation. Essentially this priority maintained the standard junction priority to vehicles on the near side that was used at other junction types. In the newer Dutch design the entries are not flared, they enter the roundabout along a radius, the circulation is one lane wide, and traffic on the circulation (off-side traffic) has priority.

The new design resulted from research carried out by the Dutch Centre for Research and Contract Standardization in Civil and Traffic Engineering (CROW) (T de Wit, 1993). These new-style roundabouts, with the approach roads linked radially rather than tangentially, force a reduced entry speed, and create the opportunity to build to much tighter dimensions than the designs with flared entries.

Five design elements have proved to be of great significance for the effective functioning of roundabouts. These relate to the internal radius, the external radius, the carriageway width, the connecting bends of approach and exit roads and the application of central guard rails. Although the dimensions of these separate elements are important, it has been proven that the overall cohesiveness is of particular significance. On specifying dimensions for a roundabout, explicit account must be taken of the ease of passage for large motor vehicles: buses and heavy goods vehicles.

At present about 50 or 60 of the new roundabouts are being constructed in the Netherlands each year. In 1993 Bosch estimated that the number of new roundabouts was more than 200 (Bosch, 1993). Where intersections have been converted into roundabouts, the total number of registered accidents has been reduced by almost 50% and the number of casualties was reduced by about 70%. The reduction in casualties at junctions outside built-up areas was 86%, which is greater than the reduction within built-up areas, 69%. However, the reduction in the number of casualties among cyclists and moped riders was less than that for car occupants: the reductions were 30% for cyclists, 63% for moped riders and 95% for car occupants.

The Dutch have studied cycle accidents in relation to traffic flow at roundabouts and conclude that cycle accidents are rare at those of the new roundabouts with a daily traffic flow of 8,000 to 10,000 motor vehicles regardless of whether there are facilities for cyclists. On roundabouts with more than 10,000 mvs/day, they judge it necessary to provide a separate cycle track on the grounds of road safety. Dutch research has also shown that roundabouts with low cycle flow and high motor vehicle flow are less safe for cyclists than those with more cyclists.

There are five levels of provision for cyclists at Dutch roundabouts:

1 mixed flow;

2 cycle lane with no physical separation;

3 cycle lane separated by ‘hedgehogs’ (narrow dividing shoulders);

4 separate cycle track with cyclists not having right-of-way;

5 separate cycle track with cyclists having right-of-way.

The choice of design was governed primarily by what they term the ‘function level’ of the cycle route:

For *through cycle routes*, a separate cycle track is preferred. Exceptionally, a cycle lane on the roundabout is allowed, but only where the daily mv flow is under 10,000 and there are no cycle tracks provided on the approach roads. At the time of the visit, cyclists following the cycle route were usually given priority over intersecting traffic.

For *distributor and access cycle routes*, there are 4 recommendations:

- a separate cycle track where daily mv flows exceed 10,000;
- a cycle lane on the roundabout where mv flows are under 10,000/day, and if there are no cycle tracks on approach roads;

- cyclists mix with other traffic where mv flows are under 8,000/day;
- cyclists on separate cycle lanes or tracks do not have priority over intersecting traffic at roundabouts outside built up areas nor at roundabouts on main roads in built up areas provided that design requirements for 'stopping chance and time loss' are met.

It is thought very important to try to achieve uniformity when setting priorities. Consecutive roundabouts with separate cycle tracks should have a consistent priority rule, avoiding confusion caused by giving cyclists right-of-way on one but not on another. The Dutch road safety statistics indicate that roundabouts with separate cycle tracks where cyclists are not given priority over intersecting traffic are safer than roundabouts where cyclists have priority and there are moves to standardise on the safer design (CROW-Werkgroep 'Verkeerspleinen II, 1993).

In principle it is *not* advisable to construct roundabouts with a cycle lane. Due to the application of a cycle lane the road surface of the roundabout is widened to such an extent that the speed of motor traffic increases. If it is not possible to construct a roundabout with a separate cycle track, but it is still desirable that cyclists be separated from motor traffic, then a roundabout with a cycle lane separated from the carriageway by a physical barrier is the suggested alternative.

The Dutch have found that, in principle, roundabouts with separate cycle tracks are preferable for situations outside built-up areas. It is recommended that cyclists are not given right-of-way at these junctions.

The sites visited were:

Enschede - the Knalhutteweg - Broekheurnering 'rotonde' (the Dutch word for roundabout). This is the trunk road roundabout featured on the cover of the C.R.O.W. publication 'Rotondes'. It has four single-lane dual-carriageway entries and two minor road entries. From photographs, the central island is about 13m diameter, with a broken white line increasing the visual radius of the island by about 1m. The remaining part of the circulating carriageway is about 4m wide. The island is formed by a low sloping wall in white brickwork. A red-surfaced cycle track runs around the roundabout, at about 4m from the circulating carriageway and separated from it by kerbed islands.

Plate E1 shows the approach view from one of the dual-carriageway entries. The red-surfaced cycle lane on this road veers away from the carriageway to form a separate entry to the roundabout. There are no advance warnings of the cycle lane (ie before the cycle lane give-way markings at the edge of the cycle lane) for the approaching drivers, neither on the road in the photograph nor on any of the other arms.

For a British cyclist the most unusual feature of the cycle track is that it has priority over the road traffic, whether entering or leaving the roundabout. It also has priority over the cycle tracks joining it. The footway and what appear to be advisory pedestrian crossings (delineated by broken white lines) form another circle further away from the roundabout, thus minimizing conflicts with cyclists. Plate E2 shows the Give Way markings to the red cycle track for traffic entering and leaving the roundabout. The footway is to the left of the cycle track, ie further away from the roundabout. The cycle track was occasionally being used in both directions, as can be seen in the photograph in which the female cyclist with the dog on a lead is riding contra-flow.

Altogether, the roundabout, cycle track and footway take up a large area. It is interesting to note the narrow width of the circulating carriageway in relation to the radius of the whole system.

Traffic was fairly light, but included a high proportion of heavy vehicles, including some very large articulated lorries. There was a steady influx of cyclists, most of whom kept to the cycle track. Give-way behaviour on the part of motorists appeared to be exemplary: numerous incidents were seen of drivers, both entering and leaving, giving way to circulating cyclists. In Plate E3, the drivers of the truck entering the roundabout and the car leaving it are giving way to the circulating cyclist.

Traffic speed appeared moderate to slow compared with that typical at a similar sized roundabout in Britain. In the case of very large vehicles, the speed was slow. Those making left turns (what would be right turns in Britain) used the additional width of carriageway within the broken line around the central island. Tyre marks on the white wall at the central island (Plate E4) indicated that some drivers misjudged this manoeuvre.

Zwolle The busy roundabout immediately outside the railway station has a red-surfaced cycle lane marked with a broken white line on the circulating carriageway. The cycle lane is continuous ie there are no gaps at the exits.

The footway crosses entries and exits quite close to the carriageway, as can be seen in Plate Z1. The red surface of the cycle lane and tracks shows up well in fine weather. This coloured surface is discontinued where the cycle tracks on the approaches and exits cross the pedestrian crossing area (Plate Z2). In the short time of observation of this roundabout, the give-way behaviour of drivers seemed satisfactory. Plate Z3 shows a typical situation in which drivers from both directions, incoming, and leaving, are giving way to a circulating cyclist using the cycle lane.

This roundabout has a minor road entry close to one of the cycle track entries, Plate Z4. Carriageway markings including give-way triangles and the words 'pasop bus' (literally 'watch out for bus', so it is assumed that the minor road traffic is buses only) provide warnings specifically for cyclists.

2.3 Germany

Bremen

The 'Stern' roundabout in Bremen is a long-established example of a roundabout modified to improve cycling safety. 'Before' and 'after' photographs of it are shown in the document Pro Fahrrad (Schäfer-Breede et al, Umweltbundesamt, 1986). It is complicated by tram lines running across its centre. Traffic signals stop the roundabout traffic for the trams; at other times the traffic movements are not signalled. There was a moderate to heavy flow of motor traffic and near continuous use by



Plate E1 Knalhutteweg – Broekheurnering ‘rotonde’: cycle lane to cycle track on approach road



Plate E2 Knalhutteweg – Broekheurnering ‘rotonde’: one cyclist in each direction, one with a dog on a lead



Plate E3 Knalhutteweg – Broekheurnering ‘rotonde’: entering truck and exiting car giving way to circulating cyclist



Plate E4 Knalhutteweg – Broekheurnering ‘rotonde’: central island; entering car giving way to cyclist on cycle track



Plate Z1 2 cyclists in lane, 1 outside it



Plate Z2 Cycle lane exit; red surface stopped at ped crossing



Plate Z3 Drivers in both directions giving way to cyclist



Plate Z4 Cycle lane entry complicated by minor access road

cyclists during the visit. The surface of the roundabout is of stone setts, as it was before modification. Brown brick has been used for the circulating cycle lane, and red brick for the connecting cycle tracks.

In Germany, at unmarked junctions, traffic coming from the near-side has priority. Where the edge of a carriageway is marked by a painted line or by a kerbed edge carried across another carriageway, vehicles on the carriageway with the line have priority over vehicles crossing the line. This system of defining priorities seems to have been carried over to the junctions making up the roundabout at Bremen to establish the off-side priority rule for traffic on the circulation.

The arrangement for cyclists can be seen in Plate Br1. The cycle lane around the nearside of the circulating carriageway is discontinued at the two junctions with tram lines, where give-way markings have been provided for cyclists. At other junctions, the cycle lane is continuous giving the cyclists priority. It should be noted that other traffic does not use the tramway. Thus, circulating cyclists have priority over all the incoming traffic apart from trams.

The cycle lane is delineated with a solid white lane between junctions and a broken white line across junctions, as can be seen in Plate Br2. In this photograph, the car leaving the roundabout is giving way to the circulating cyclist. Generally, cyclists used hand signals to indicate that they were continuing past an exit, and they also appeared quite fastidious about hand-signalling that they were leaving the roundabout. Traffic speed was quite low, and drivers appeared to be careful towards cyclists. There were several family groups with young children on their own cycles using the roundabout, and some unaccompanied children, too.

One difficult feature of this large roundabout is a dedicated right-turning lane. Plate Br3 shows this lane, and the arrangement of cycle lanes made necessary by it. Drivers generally gave way to cyclists using the right-angled crossing, which is marked by a broken white line delineating both sides of the red cycle route. Plate Br4 shows the view back along the right-turning lane. The refuge at the start of the right-turn lane does not appear in the ‘after’ photograph in ‘Pro Fahrrad’ so presumably was added to give cyclists crossing from the circulating cycle lane some protection, in addition to the broken painted line, when about to cross the right-turn lane.

2.4 Denmark

In 1976 the near-side give-way rule at roundabouts was changed to an off-side give-way rule ie giving priority to traffic on the circulation (Kjemtrup, 1993). Roundabouts became a favoured junction form because they allowed higher traffic flows and there were fewer accidents than at other junction types. However, with increasing cycle traffic, cycle accidents at roundabouts became more frequent. Accident studies showed that the predominant roundabout accident (47% of the total) involved a circulating cyclist hit by an entering or leaving motor vehicle. In the mid-80s work began on new guidelines for roundabouts. ‘The English philosophy that a roundabout should be dynamically designed to be an effective traffic handling machine was abandoned’ (Kjemtrup, 1993). Instead the aim was to design for the safety of cyclists by ensuring that vehicles entered the roundabout at slow speeds and so had time to observe (and give way to) circulating cyclists.

The Danish roundabouts with cycle facilities were considered to be experimental at the time of the visit. The Danish Council of Road Safety Research (Rådet for Trafiksikkerhedsforskning) are not yet satisfied with the safety record of these roundabouts, so the designs are not prescribed. They have completed a ‘before and after’ study, with control groups, of the safety of 82 roundabouts built since 1985 (Joergensen and Joergensen, 1994). Four-fifths of these roundabouts were built with either a separated cycle track or a cycle lane in the circulating area. The other one-fifth of the roundabouts had no cycle track or lane, and had somewhat lower cycle traffic.

The findings of this Danish research are in accord with the findings of earlier work in Denmark and a study in the Netherlands (and also the British research):

- Installing a roundabout at a give-way junction reduces car accidents by 85 per cent.
- Injury accidents become less serious.
- Injury accidents are mainly cyclist accidents and the most important category is where an entering motor vehicle hits a circulating cyclist.
- Installing a roundabout changes the type of cycle accident but not the number of cycle accidents.
- There was no evidence that the provision of separate cycle tracks was safer than the provision of cycle lanes or vice-versa.
- There was no indication that cyclists were at higher risk at roundabouts where there was no separate cycle lane or track.

The Joergensens suggest that many important questions concerning the safety of roundabouts have not been covered and further studies should be carried out. These studies were just beginning at the time of the visit.

København (and area north to Helsingor)

This area provided a number of very different roundabouts with different levels of provision for cyclists. The weather during the visit was particularly bad, so there were fewer than normal cyclists.

The first example is a roundabout known as the ‘Femvejen’ (= five-arm) roundabout in Jægersborg, lacking any cycling facility and reputed to be difficult for cyclists. As can be seen in Plate K1, the expanse of tarmac gives ample opportunity for fast driving. It was found to be every bit as unpleasant for cycling as typical roundabouts in Britain.

Some roundabouts have been altered with the intention of reducing traffic speed. Build-outs have been introduced at the 3-arm roundabout in Ordrup shown in Plate K2. The viewpoint for the photograph was chosen to illustrate the minimal effect of some of these build-outs on traffic deflection.

A cycle lane with a broken white line marking and cycle



Plate Br1 Necessarily inconsistent Give-Way (to trams)



Plate Br2 Exiting car giving way to circulating cyclist



Plate Br3 Red cycle route marked across right slip road



Plate Br4 Cyclist crossing the right turn slip road

symbols is shown on the roundabout in Plate K3, also in Jægersborg. No surface colouring is provided, and the cycle lane markings are difficult to see when approaching the roundabout. The pedestrian crossing markings, set back from the roundabout, are like those for British Zebra crossings and do show up more clearly. The size of the roundabout, the width of the circulating carriageway and the amount of deflection can be judged from Plate K4.

Slightly more prominent markings for the cycle lane have been made at the roundabout in Lundtofte shown in Plate K5. The white line is continuous between junctions. Again, deflection for traffic is not particularly marked. This can be judged from Plate K6.

A greater level of cycle provision has been given at a roundabout in Holte. There are marked build-outs to narrow the entrances and exits, and the central island is made to appear larger than it is by means of an annulus of stone setts and a white line (Plates K7 and K8). The red-surfaced cycle lane is continuous around the roundabout, has a solid white line between junctions and a broken lane across them. Some cycle symbols have been painted on the cycle lane. The prominent markings for the pedestrian crossings are shown in Plate K9. (The plate also shows a cyclist leading a dog for a walk on the roundabout. It is hard to imagine this happening on a typical British roundabout, although it could have a traffic-calming effect on pet-loving drivers).

The blue surface dressing used at a 4-arm roundabout near Helsingor, Plates K10 and K11, shows up very clearly. At this site, it is used to highlight the cycle lane *only where motor traffic crosses it*. At these points, the lane is delineated with a broken white line. Elsewhere, the lane has only a solid white line, with no surface colouring. Short brick-surfaced patches have been used to separate the cycle lane from the circulating carriageway. The cycle lane is raised slightly from the carriageway, but with only a gentle slope. Likewise, the footway is slightly higher than the cycle lane, with a white line separating the two. Traffic appeared quite fast at this roundabout, presumably due to the fairly large diameter and the wide carriageway.

Give-way behaviour was inconsistent. In Plate K12, the driver leaving the roundabout is, as might be expected, giving way to the group of cyclists. Plate K13 shows a moped rider who was being prevented from continuing around the roundabout by traffic failing to give way when leaving. The give-way triangles in this photograph, behind the moped, are for cyclists entering the roundabout from a white-line-segregated cycle track. It should be noted that in Denmark, as elsewhere in Continental Europe, moped riders are treated as pedal cyclists, and are only rarely prevented (by specific signing) from using pedal cycling facilities. (Mopeds are not permitted to use cycle tracks or cycle lanes in Britain).

The central island has been enlarged with an annulus of brickwork with a solid white line, then an additional broken white line about 1m out.

The busy roundabout shown in Plate K14 is close to a massive out-of-town shopping centre and had only just been built. Surface dressings and markings for the cycle lane and tracks had not been completed. However, the important features can be seen. The central island has a much more prominent white annulus, in fairly gently sloping brickwork, and the cycle lane is separated by kerb and white line between the junctions. It was intended to provide the usual pale blue surface dressing where the cycle lane crossed entries and exits. Plate K15 shows a detail at one of the fairly narrow exits, where a cycle track is separated from the circulating cycle lane by a raised area of stone setts. The markings for the pedestrian crossing extend across the cycle track. Footway and cycle lane and tracks were separated by either a white line or a narrow strip of grass.

Because of the incomplete markings, it was not possible to judge how cyclists fared at this roundabout.

A greater degree of separation has been used at the roundabout in Helsingor shown in Plate K16. Cyclists have a cycle track separated by a shrub border from the carriageway. They have to give way to traffic at the entries and the exits at points about a car's length from the roundabout (Plate K17). The use of give-way triangles on the cycle track was not consistent - some points had no markings and, where markings were installed, they were located in the assumption that cyclists would always ride clockwise. They did not.

The signing at this roundabout could be confusing. In Plate K17, the warning triangle just before the cycle lane is intended presumably to warn drivers about the pedestrian crossing just beyond the cycle lane. The give way line across the cycle track tells cyclists that they must give way to traffic leaving the roundabout but this may not be obvious to drivers. In Plate K18, pedestrians crossing have priority over vehicles entering the roundabout but cyclists moving parallel to the pedestrians on the adjoining cycle track do not have priority.

Traffic towards Helsingor approached this roundabout downhill on a dual carriageway. This led to high entry and circulating speeds and it was very difficult for pedestrians to cross the main traffic flows even at the designated crossing places such as that shown in Plate K18.

Nakskov

The roundabout in Nakskov was observed on an overcast then very wet day when there were few people out on the roads. It has the unusual feature of speed control humps across all entries and exits (Plate N1 and N2). The humps were quite low, and had gentle slopes - perhaps 1 in 25. The ramps on both sides of the humps were made of coarse stone setts and acted like rumble strips, making the site noisy. They were not wholly successful in slowing traffic. As at other sorts of vertical deflection, some drivers slowed down but some did not. The kerb-separated cycle lanes on the connecting roads effectively give cyclists a bypass to the humps. Signs on the approaches warned of the roundabout and the pedestrian crossings, but there was no specific warning of the humps.

For environmental reasons, the cycle lanes in Nakskov are in red asphalt instead of the pale blue colour that has now become the Danish standard. The municipality was granted special dispensation for this by the Ministry of Justice.



Plate K1 5-arm: (‘Femvejen’) Jægersborg Allé *2/Vilvordevej/ Ordrupvej/Bernstorffsvej



Plate K2 Entry build-outs, Hyldegardsvej/Tværvej; in Ordrup



Plate K3 5-arm: Jægersborg Allé *2/Skovvej/Vældergårdsvej/ Søndersøvej



Plate K4 Jægersborg Allé *2 / Skovvej, District: Jægersborg: cycle lane marked with white lining + symbols



Plate K5 5-arm: Ørholmvej/Kulsviervej *2/Nøjsomhedsvej/ Egegårdsvej; District: Lundtofte: no coloured surface for cycle lane



Plate K6 5-arm: Ørholmvej: pedestrian crossing extends over cycle track



Plate K7 4-arm: Dronninggards/Rønnebærvej near railway line, Holte. Approaching from east



Plate K8 Dronninggards: white line, stone setts around island



Plate K9 Dronninggards: taking dog for walk on roundabout cycle lane



Plate K10 Kongevejen/Støberivej, SW of Helsingfor: blue surface and symbol wearing thin



Plate K11 4-arm: Kongevejen/Støberivej.: blue surfaced lane across entries & exits



Plate K12 Kongevejen/Støberivej: car giving way to circulating cyclists



Plate K13 Kongevejen/Støberivej: m/cyclist giving way to traffic leaving



Plate K14 4 arm: Kongevejen/Klostermosevej, near Prøvestenscentret: no lane markings across entries & exits



Plate K15 Kongevejen/Klostermosevej: stone setts separating c. lane and track



Plate K16 3-arm: Flynderborgvej/Færgevej, just south of Helsingør Centrum: cycle track separated by shrub border



Plate K18 Flynderborgvej/Færgevej: pedestrian crossing markings worn away



Plate K17 Flynderborgvej/Færgevej: cycle track and footpath separated, too

On the roundabout, the red cycle lane is separated from the circulating carriageway by about 0.5m width of brick surface then a white line, as usual solid between junctions, broken at them. Plate N3 shows this arrangement, together with one of the unusually positioned bollards at the entries.

The size of the roundabout, and the effectiveness, or otherwise, of the stone setts around the central island may be judged from Plate N4. It was noted that the red surfaced cycle lane cannot be distinguished when approaching the roundabout until within about 15m, though the Zebra type pedestrian crossing markings are visible from a considerable distance. Wet weather with a dark sky made the red lane more difficult to see.

This unusual roundabout did seem to have some good elements, but the overall effect was not satisfactory. Speed reduction had not been achieved. The humps were very shallow, and the width of carriageway allowed fairly fast circulating speed. As with some other Danish roundabouts, the priority rule seemed unclear at exits, possible because of the broken white line along the cycle lane. It looked as though cyclists were being forced into risky locations where their well-being was dependent on whether drivers understood rather ill-defined priority rules.

Odense

The Danish design of kerb side cycle lanes surfaced in pale blue was highly visible when close to and on the roundabout, and appeared to be well understood. The opinion of some taxi drivers was that they liked the blue marking because it shows up well, even in poor lighting and weather conditions, and everyone knew what it meant.

Two roundabouts in Odense were visited. The view for an approaching driver of the 4-arm Hans Mules Gade/ Østergade roundabout is shown in Plate O1. At this distance, the pale blue cycle lane is just visible. As elsewhere, there are no special warnings to road users of any cycling facilities at the roundabout. The blue cycle lane is delineated with a white line, broken at each arm of the roundabout but solid in between. White cycle symbols have been painted on the lane at potential conflict points (Plate O2). The width of carriageway allowed for relatively fast driving.

This site was visited on a Saturday afternoon when traffic was light (the Danes do not trade on Saturday afternoon or Sunday). It was found to be extremely unnerving cycling very close to entry give-way markings when there was a motor vehicle approaching the roundabout quite fast. As in Britain, some drivers there tend to brake at the last moment, so it was often not possible to judge whether they were going to give way. The nearside cycle lane puts cyclists in the most dangerous position on a roundabout ie close to the entry. If an entering driver fails to give way, a cyclist in the lane does not have the time or the space to avoid being hit. Not all cyclists use the cycle lane (Plate O3); whether they are avoiding this danger or just taking the shortest route is not known. Some other cyclists were seen to use the peripheral footways instead (Plate O4).

It should be noted that the give way markings on the approach roads are ahead of the pedestrian crossing



Plate N1 Road markings only used as a warning of ramp



Plate N2 Cycle lane separated from carriageway by using bollards, stone setts and paint



Plate N3 Bollard, red lane, stone setts and ped crossing



Plate N4 Red lane in distance does not show up well in damp weather

markings, and the small gap between this crossing and the blue cycle lane is presumably not intended as a second give way position for incoming drivers. This means that a driver has to make a decision about giving way to a circulating cyclist at quite some distance back, in order not to stop on the pedestrian crossing.

The 6-arm roundabout at Kochsgade/Døckerslundsvej/ Bellisvej/Risingsvej was visited very early on a Sunday morning when there was little traffic and very few cyclists. Details of this roundabout are given in 'An Improved Traffic Environment: A Catalogue of Ideas' (Danish Road Directorate, 1993). The roundabout was established in 1939 and renovated in 1990/91. Its central island is 17m radius, the width of the circulating carriageway is 8m plus a 2m wide cycle lane. AADT is about 14,000 vehicles. The report mentions that, before renovation, there were 7.3 accidents a year. An 'after' figure was not given, presumably because of the short 'after' period.

As at Hans Mules Gade/Østergade, the pale blue cycle lane on the Kochsgade roundabout is highly visible (Plate O5). A small general store immediately adjacent to the roundabout attracts drivers who park on the circulating carriageway. The van is parked on the outside of the cycle lane, the car has been left on the cycle lane. This parking is probably less likely when more traffic is about.

There is a small amount of separation between the cycle lane and the nearside of the circulating carriageway (Plate O6), so small that it is not likely to make much difference to the level of risk for cyclists crossing in front of the entries.

The view for an approaching driver is shown in Plate O7. The hedge growing on the central island cuts out visibility across the junction. It can be seen that the pedestrian crossing area shows up well, but the cycle lane is not so prominent. One small feature seems incongruous - the kerb-separated cycle lane on this approach road is discontinued well before the roundabout, in effect introducing a fairly wide flare.

At this roundabout, and seen commonly elsewhere, the blue surface dressing was wearing off. In Plate O8, this is noticeable where traffic leaving the roundabout crosses the cycle lane. The Danish Road Directorate are already aware that this particular dressing does not last very long.

3 Summary and recommendations

This report describes a study tour of some roundabouts in Continental Europe where there are cycle facilities or where the roundabouts were designed with cyclists in mind. Observations and comments have been given throughout this report under the location of the roundabout concerned. The descriptions and photographs of these schemes are intended to provide some pointers for further research and development in Britain.

Levels of cycle use are much higher in the areas visited than the average levels in Great Britain and there are more cycle facilities. Some commentators claim that these higher levels of cycle use and facilities provision make other road users so much more aware of cyclists than road users in Great Britain that accident savings at these sites cannot be translated to Britain. There is not much experimental data to refute this position: however, the one British investigation of redesigning a roundabout to reduce vehicle speeds has shown a statistically significant reduction in cyclist casualties and this does seem to match the results from the much more extensive investigations in the Netherlands.

Research in various European countries has found that roundabout junctions operating under the off-side priority rule have a higher traffic capacity and fewer injury accidents than uncontrolled or give-way junctions. However, the predominant residual accident type at such roundabouts is a cycle accident where a circulating cyclist is struck by a motor vehicle entering or leaving the circulation. Ways to reduce the number of cycle accidents at roundabouts are being sought in almost all European countries, not least because of national policies to promote cycling as a sustainable and health-improving means of transport.

In pursuit of greater cyclist safety, traffic engineers in Denmark, Germany and the Netherlands have moved from British roundabout designs with flared entries and wide circulation to a tighter geometry of radial entries and narrow circulation. In Germany and the Netherlands the newer designs do seem to have reduced vehicle speeds and researchers in the Netherlands have observed reductions in the number of cycle accidents. The Danish roundabouts visited were not as tight as the roundabouts visited in the other two countries and motor vehicle speeds were higher. It was not surprising, therefore, that research in Denmark should show no significant reduction in cycle accident numbers after the roundabouts were installed.

At the German roundabout visited and at some of the Dutch roundabouts cyclists circulating on a separate peripheral cycle track or segregated lane had priority over vehicles which were either entering or leaving the circulation. At the roundabouts observed this arrangement was working very well: the vehicles were stopping and the cyclists seemed confident that they would stop. Nevertheless, Dutch research shows some residual cycle accidents where vehicles have not given way and these roundabouts with cyclist priority are considered significantly less safe than roundabouts where cyclists are on a separate track or lane give way.

There is a need for further research on British roundabouts (extending the research in Hersham):

- to investigate how vehicle speeds through roundabouts can be reduced;
- to discover what effect vehicle speed reductions have on cycle accidents; and
- to find how the speed changes affect the traffic capacity of the roundabout.

At the same time developments in other European countries should be monitored closely:

- to evaluate the relative benefits of separate cycle tracks, cycle lanes and cyclists on the circulation; and
- to determine the best priority rule for cyclists on tracks and segregated lanes.



Plate O1 West approach to Hans Mules Gade/Østergade rbt; no special warnings about cycle lane



Plate O2 White cycle symbols are painted at conflict points



Plate O3 Not all cyclists use blue lane



Plate O4 Some ride on the peripheral footway



Plate O5 Vehicles park on roundabout near general store



Plate O6 Blue cycle lane; cyclist leaving roundabout



Plate O7 Segregated cycle lane on approach road. Note hedging



Plate O8 Blue surface wearing off at exit

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Abstract

This report describes a study tour of some roundabouts in Continental Europe where there are cycle facilities or where the roundabouts were designed with cyclists in mind. The research was undertaken on behalf of the Driver Information and Traffic Management Division of the Department of the Environment, Transport and the Regions.

Generally, the geometry of roundabouts on the Continent is 'tighter' than in Great Britain so that drivers cannot enter and leave at such high speeds. This leads to reductions in cycle accident numbers but may also reduce the traffic capacity of the roundabout.

The descriptions and photographs of these schemes are intended to provide some pointers for developments in Britain and recommendations for further research are included.

Related publications

TRL285 *Cyclists at roundabouts – the effects of 'continental' design on predicted safety and capacity* by D G Davies, M C Taylor, T J Ryley and M E Halliday. 1997 (price £30, code H)

CT2.1 *Cycling safety update (1993–1996)*. Current Topics in Transport: abstracts selected from TRL Library's database. (price £15)

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