A QUANTITATIVE ANALYSIS OF CYCLIST BEHAVIOUR AT SELECTED ROAD JUNCTIONS

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Abstract

There is currently a resurgence in the use of the bicycle as a means of urban transport. Many interventions are being planned and implemented that are intended to encourage more cyclists and there is much debate on how this should be done. This paper examines an area comparatively neglected, which is how cyclists use the existing infrastructure, road junctions in particular.

Road junctions are generally considered more likely to be the site of accidents than a straight road, hence junction design and junction use, is of critical importance. Junctions selected for observation include traffic-light controlled junctions and a roundabout. Junctions include at least one branch with cycle lanes, so as to include an assessment of their use. Data collected is restricted to counting cyclists and observing their use of the junction i.e. their approach, exit and route choice: on-road or off-road.

Three main conclusions emerge: first, that cycle-training is an investment that would be very beneficial; second, that pedestrian crossings at large roundabouts are a critical enabling factor for the vast majority of cyclists unwilling to ride as vehicular traffic; third, that even at traffic light controlled junctions with some cycle lanes, only a minority of cyclists use them in the manner implied by their design.

Introduction

There is great diversity to be seen in cyclist behaviour, more so than in motorist behaviour; in particular, some cyclists, some of the time, behave more like pedestrians than vehicular traffic, or more popularly, they ride on the pavement. This behaviour expresses the dilemma facing modern cyclists, who have a choice, between riding on the road, where many feel unsafe, or on the pavement, where they risk disapproval, or worse. In practice, cyclists may well switch between an on-road and off-road riding style during a journey, and even while negotiating a single junction. This creates significant difficulties for the authorities responsible for traffic management and for those representing cycling interests.

This on-road / off-road duality is usually expressed under the “segregation” banner. Segregation is the policy of attempting to separate cycle traffic from motor traffic, but this poses an essential difficulty, that segregation is essentially aspirational, and can never be fully realised, since it is manifestly impossible to build a cycle network that completely duplicates the existing road network. In practice, the debate hinges on which roads should carry cycle facilities and what type should be implemented; difficulties are naturally most acute at junctions. Some forms of segregation inevitably challenge the interests of both motorists and pedestrians; segregation is therefore both complex and contentious[1].

Segregation can be considered from two angles; the most commonly discussed is from the point of view of the traffic engineer, and other interested parties, who consider what type of infrastructure is appropriate. The other angle is from the point of view of the cyclist, who makes continuous decisions on riding style, as suggested above; on a straight road this may be a simple decision on whether or not to use a cycle path / lane[i], if offered. Segregation becomes much more complex at junctions, where full segregation is usually impossible[ii] and the cyclist has to deal with partial or no segregation. It is this second aspect that is considered in the present paper.

In common with other European countries, the Irish authorities have implemented both on-road and off-road facilities, a compromise that reflects both accepted practice, but also

(i) Following common usage, we use the terms “cycle lane” for on-road cycle facilities and “cycle path” for off-road cycle facilities; these two main types are distinguished essentially by whether the cyclist is on the same level as, and shares space with, either motor vehicles or pedestrians

(ii) Many signalised junctions already seek to cater for both motorists and pedestrians, separately; to add cyclists as a third category is to incur greater complexity; this has been attempted on the continent, but not, so far, in Ireland

faces the complexities suggested. Cycling interests face their own difficulties: they are familiar with risks associated with segregation[2], and may be ambivalent about it, hence risk incomprehension or worse from the wider public, most of whom are in favour of segregation.

Research Background

Cycling rates in the Limerick City area are generally low[3]; this means that at most locations, in a reasonable survey time, only a small number of cyclists are likely to be seen, making it difficult to accumulate meaningful data. For this and other reasons, survey locations were selected around the University of Limerick, where a higher volume of cyclists is to be seen, at least at peak hours, and during the University terms. The locations chosen were (described in more detail below):

- The east entrance to the University
- The west entrance to the University (by the flagpoles)
- The Groody roundabout, some 0.5km from the University, on the Dublin Road

The entrances to the University are on a road that has cycle lanes, which is partly why these locations were chosen, as the way that cyclists use cycle lanes is relevant to this study.

A key difficulty is the diversity of cyclist behaviour observed. Consider for example, a 4-way junction, or crossroads; this may be approached from one of four directions, and in each case one of three choices made: turn left, turn right or straight on. This makes 12 options, for a driver; but a cyclist may use a cycle lane, if there is one, or perhaps the pavement, and may do so in a number of different ways. This quickly creates a very large number of possible behaviours. To address this, behaviours were categorised into a smaller number of cases. Each junction required separate analysis to determine the optimal way to log and present the data.

The basic method was to count cyclists in each category defined for the junction. Further analysis included the following: whether the cyclist was on-road[iii] or off-road, whether the cyclist was wearing a helmet and gender. Locations were observed for periods from 30 minutes to an hour. The total number of cyclists observed varied from about 35 to 60 cyclists, per hour. Each junction was observed several times; in general, the variability of data gathered for a particular junction, at a particular time, was not great. All data is included in this paper.

East entrance to the University

This T-junction is one of two vehicular entrances to the University, both from the Plassey Park Road, the other is a few hundred metres further along the road[iv]. This is a signalised junction. The majority of the traffic entering the University, in the morning, is turning right into the University, hence is turning left out of the University in the evening. This junction was monitored in the morning only, as it is more interesting to look at how cyclists negotiate a right turning than a left turning.

UL East Entrance Morning		Vehicular Traffic	Day / Date / Time / Weather Overall totals					Totals	Percentage of total	Notes
			Tue 9 Apr 2013	Wed 10 Apr 2013	Tue 16 Apr 2013	Wed 1 May 2013	Thu 2 May 2013			
			08:20–09:20	8:45-09:15	8:20-9:10	8:15-9:05	8:15-9:05			
			Overcast, cold	Sunny, mild	Overcast	Overcast	Sunny, cool			
Plassey Park Road turning right into UL	Correctly executed right turn, all on-road	Y	8	12	13	10	7	50	33%	Vehicular traffic
	Correctly executed right turn, then switching to left side footpath	N	5	2	4	3	5	19	12%	Probably because lanes are narrow and some cyclists unwilling to command lane
	Approaching on left (i.e. correct) side of road, then crossing like a pedestrian	N	3	1	3	3	2	12	8%	Some ride
	Approaching on cycle path or footpath, on the right (i.e. wrong) side of the road	N	5	3	4	2	4	18	12%	Some then cross after turning to become on-road again
Plassey Park Road turning left into UL	On-road	Y	0	0	1	1	0	2	1%	Most cycle traffic from the east probably uses the west (flagpoles) entrance, or cuts through Milford, church / school
	Off-road	N	0	0	1	1	3	5	3%	
PPR straight on	Either direction	Y	4	4	6	8	9	31	20%	One or two ride on the pavement or the wrong side of the road
Leaving UL	Turning left or right	N	6	3	2	1	4	16	10%	Most off-road
Totals	**All routes**		**31**	**25**	**34**	**29**	**34**	**153**	**100%**	

(iii) The cyclist had to negotiate the whole junction on-road to be categorised as such

(iv) There are no other vehicular entrances to the University, although there is pedestrian / cycle access to the campus from the river path, which is used by a number of commuters (not counted in this study), mostly to / from the city, which is about a 15 minute ride

Additional analysis										Notes
Breaking red lights			0	0	0	1	2	**3**	2%	Nothing hazardous seen
Wearing a helmet			8	6	12	10	8	**44**	29%	
Skate-boarder			1	1	1	1	1	**5**	3%	
Gender	Male		22	22	26	22	21	**113**	74%	
	Female		9	3	8	7	13	**40**	26%	
On / off road	As vehicular traffic	Y	12	16	20	19	16	**83**	54%	
	Partial or complete use of footpaths / off-road cycle paths	N	19	9	14	10	18	**70**	46%	

The cycle lanes on the Plassey Park Road can be seen[v]; note that the westbound cycle lane offers a right-turn cycle lane, as well as the straight-on cycle lane, but that eastbound the cycle lane is straight-on only i.e. does not offer a left-turn filter[vi].

Analysis

The primary observation is that of the cyclists making the right turn into the University, only half[vii] use the cycle lane provided in the manner intended[viii]; 20% use the cycle lane to make the turn, but then immediately switch to the footpath; a further 12% approach the junction as if to go straight on and then cross at one of the two sets of pedestrian lights, like a pedestrian, although not necessarily dismounting. The remaining 18%, the least compliant, approach the junction on the other (wrong) side of the road, some on the footpath, and some on the cycle lane, which means they are cycling on the wrong side of the road; this could be interpreted as a manoeuvre made opportunistically, some distance further back, when the road was momentarily free of traffic, presumably to minimise engagement with the junction.

These cyclists turning right comprise 65% of the total users of the junction; a further 20% are going straight-on and 10% are leaving the university campus. A small proportion (4%) turn left into the University; there are very few of these because most of the cyclists coming from the west will probably use the west entrance; some of them may also cut through nearby Milford church and school to the campus.

The overall proportion of cyclists behaving as vehicular traffic is 54%. Very few cyclists were seen breaking red lights[ix], and none appeared to do so dangerously.

Commentary

The data raise the obvious question: Why do many cyclists not use the cycle lanes provided in the manner intended? This is not an easy question to answer. An obvious factor is probably fear, particularly an aversion to crossing lanes of traffic; another possible interpretation is lack of discipline or training.

A second aspect is the disinclination many cyclists show to using the road once inside the University campus; as noted, nearly half[x] the cyclists using this junction do so off-road and of the cyclists that make the right-turn correctly, on-road, a number[xi] then switch to the footpath. This is more easily interpreted: the access road is quite narrow[xii], hence cyclists cannot be safely overtaken on it; this leads to cyclists feeling intimidated, hence they choose the footpath.

The specific conclusion is that the provision of a right-turn filter cycle lane is under-utilised at least partly for lack of a cycle lane, or a sufficiently wide carriageway, on the road turned into.

(v) See page 4 for a panoramic view of these junctions

(vi) Neither does the other (west) entrance, nor do most other similar junctions

(vii) 50 of 99

(viii) As vehicular traffic

(ix) 3 of 153

(x) 70 of 153

(xi) 19 of 69

(xii) 7m i.e. a lane width of 3.5 m, which is too narrow for safe overtaking, as cyclists need at least 1.5 m of road space

East entrance to University

West <----------> East

West Entrance to University

West entrance to the University

This junction is the second of the two vehicular entrances to the University, from the Plassey Park Road. This is also a signalised junction, and is somewhat more complex, as it is a crossroads, rather than a T-junction, and there is a cycle lane on the branch leading into the University campus[xiii].

Morning

UL West – Flagpoles Entrance			Vehicular Traffic	Day / Date / Time / Weather			Overall totals	Percentage of total	Notes
				Thu 4 Apr 2013	Thu 11 Apr 2013	Mon 29 4/4			
Morning				08:05–09:05	08:30–09:00	8:30-09:05			
				Sunny, cold	Overcast	Sunny, cool			
L1	Plassey Park Road turning left into UL	On-road, executing correct left hand turn	Y	5	1	2	**8**	7%	Probably not intending to use pedestrian crossing further on
L2		Off-road, behind or in front of monument	N	22	17	19	**58**	49%	Probably intending to use pedestrian crossing further on
L3a		On-road, but after turn, cross to reach cycle lane by flagpoles	N	2	4	11	**17**	14%	
L3b		Approaching junction on "wrong" side of road, then using ped. x-ing	N						
L3c		As L3b, but using other ped. X-ing, to reach cycle lane per L3a	N						
R1	Plassey Park Road turning right into UL	Executing correct right hand turn	Y	0	1	2	**3**	3%	
R2		Crossing PPR at or before traffic lights	N	5	1	4	**10**	8%	
EW	PPR straight on	Eastbound or Westbound	Y	12	2	5	**19**	16%	
S1	From. Plassey Village	Heading into UL	N	0	2	1	**3**	3%	Using pedestrian crossings, in every case
Totals		**All routes**		**46**	**28**	**44**	**118**	**100%**	

Additional analysis						Notes
Using pedestrian crossing after entering UL			15	14	16	**45**	38%	To reach cycle track on the other side of the road
Wearing a helmet			8	1	1	**10**	8%	
Gender	Male		36	20	32	**88**	75%	
	Female		10	8	12	**30**	25%	
On / off road	As vehicular traffic	Y	17	4	9	**30**	25%	
	Making partial or complete use of footpaths / off-road cycle paths	N	29	24	35	**88**	75%	

Evening

UL West – Flagpoles Entrance			Vehicular Traffic	Day / Date / Time / Weather			Overall totals	Percentage of total	Notes
				Mon 29 Apr 2013	Tue 30 Apr 2013	Wed 1 May 2013			
Evening				4:50-5:30	5:10-5:50	4:55-5:45			
				Bright, cool	Bright, cool	Sun, wind			
R1	Turning right out of UL	On road – as vehicular traffic	Y	2	3	3	**8**	8%	
R2		Off-road, either in front of, or behind monument	N	10	7	21	**38**	39%	Vast majority have used the pedestrian crossing just before the junction
R3		Using pedestrian crossing to reach cycle lane on the correct side	N	0	1	1	**2**	2%	
R4	Turning right into UL	On road – as vehicular traffic	Y	0	0	0	**0**	0%	
R5	Turning right into UL	Off road – as vehicular traffic	N	0	1	1	**2**	2%	
L1	Turning left out of UL	On or off road	N	1	1	2	**4**	4%	
L2	Turning left into UL	On or off road	N	1	6	2	**9**	9%	
S1	Plassey Village – UL	On road – as vehicular traffic	Y	0	2	1	**3**	3%	
S2	Plassey Village – UL	Crossing lights, as a pedestrian	N	4	0	3	**7**	7%	
EW1	PPR straight on	Eastbound or Westbound	Y	5	5	9	**19**	20%	
EW2	PPR straight on	Eastbound or Westbound; on the "wrong" side of the road	N	1	2	2	**5**	5%	One on the pavement, not the cycle lane
Totals		**All routes**		**24**	**28**	**45**	**97**	**100%**	

Additional analysis						Notes
Wearing a helmet			3	3	8	**14**	14%	
Breaking red lights			4	0	4	**8**	8%	
Gender	Male		18	21	34	**73**	75%	
	Female		6	7	11	**24**	25%	Two with child in carrier
On / off road	As vehicular traffic	Y	7	10	13	**30**	31%	
	Partial or complete use of footpaths / off-road cycle paths	N	17	18	32	**67**	69%	

(xiii) But on one side of the road only, see commentary later

Analysis

This junction was observed in both the morning and the evening. The dominant traffic flow is a left turn into the University in the morning, and a right turn out of it in the evening. Like the simpler east entrance junction, there are cycle lanes on the Plassey Park Road, offering a right-turn filter cycle lane, into the University, from the east, but no left-turn filter cycle lane from the west[xiv], from which most of the traffic comes, in the morning.

In the morning, most[xv] of the cyclists using this junction are turning left turn into the University i.e. from the west; of these left-turning cyclists, the majority[xvi] approach the junction on the footpath (the cycle path offers straight-on only, as noted above[xvii]); most[xviii] of these cyclists then use the pedestrian crossing a few metres further on to reach the one-sided cycle lane leading into the campus. Only a small proportion[xix] of cyclists execute an on-road left turn. A larger minority[xx] approach the junction in various other ways[xxi] to reach the one-sided cycle lane leading into the campus. The second most common usage pattern, in the morning, is the 16% of cyclists who use this junction straight-on. Overall (in the morning), 25% of cyclists behave as vehicular traffic.

In the evening, the dominant[xxii] traffic flow is the converse, that is cyclists turning right out of the University. Of those cyclists, the majority[xxiii] also do so off-road, hence making the cycle-path between this junction and the Groody roundabout bi-directional. The second most common usage pattern, in the evening, is the 25% of cyclists who use this junction straight-on[xxiv]. Overall (in the evening), 31% of cyclists behave as vehicular traffic.

Commentary

Like the previous junction, the east entrance to the University, the data raise questions on the use of cycle facilities. The dominant cycle flow in the morning (left turn into the University) is poorly supported, as far as segregation goes; there is a cycle lane leading into the University, but it is on the wrong side of the road for cycle traffic turning left into the campus and further, the footpath on the side being used, entering the university, soon ends, forcing use of a pedestrian crossing a few metres further on. It is therefore not surprising that most cyclists adopt an off-road riding style.

In contrast, the dominant cycle flow in the evening (right turn out of the University) is actually well supported for on-road cyclists; however, only a small minority[xxv] of cyclists take advantage of the infrastructure offered and most[xxvi] do the inverse of the pattern observed in the morning i.e. ride entirely off-road. Further, by not executing an on-road right turn, many of these cyclists end up on the other (wrong) side of the road; some of them will have to cross the road again, at the Groody Roundabout[xxvii].

(xiv) Probably mostly via the Groody roundabout, see next section

(xv) 83 of 118

(xvi) 58 of 83

(xvii) Additionally, the stretch from the Groody roundabout to this junction is a cycle path i.e. off-road, which probably increases the proportion of cyclists who stay off-road using the junction

(xviii) 45 of 58

(xix) 8 of 83

(xx) 17 of 83

(xxi) See data for brief details

(xxii) 48 of 97, or 49%, somewhat anomalously, as the morning proportion is 70%; this is probably because the University commuting pattern is much more irregular than standard office hours

(xxiii) 38 of 48

(xxiv) Of this 25%, 1/5 of them rode on the wrong side of the road, and one of them on the pavement

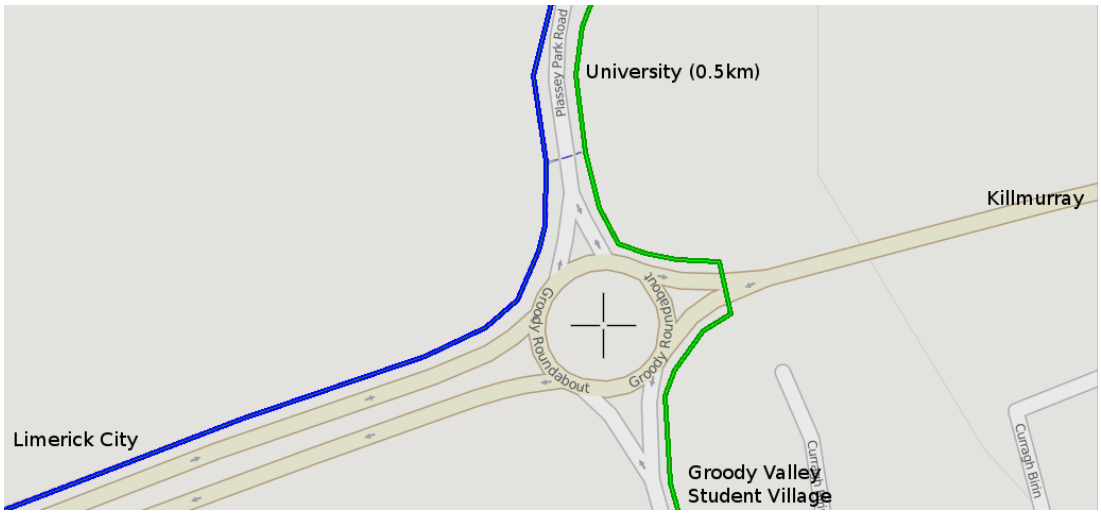
(xxv) 8 of 48

(xxvi) 40 of 48

(xxvii) See next section

Groody Roundabout

This roundabout is on the Dublin road, about 3km from Limerick city and is one of the largest and busiest junctions in the Limerick area. Nearly all the traffic that uses the west entrance to the University will also use this roundabout. Pedestrian crossings were added to this roundabout some years ago, and are heavily used by cyclists.



The dominant (cycle) traffic flows are shown above, in blue and green; the green route (to the Groody Valley student village) accounts for 44% of the total traffic and it is notable both that there are many pedestrians[xxviii] using the same route and that there is a free bus service[xxix], hence cyclists may be presumed to be cycling from choice rather than necessity.

Analysis

The main observation is that most[xxx] cycle traffic is entirely off-road, using the cycle-paths and pavements and the pedestrian crossings. This means that the pedestrian crossings are an essential facilitator of cycle (and pedestrian) traffic on this busy roundabout; it also means that many cycle-paths and pavements carry bi-directional[xxxi] cycle traffic.

Overall Gender Analysis

The table below shows the gender analysis across all three junctions; it is noticeable that the gender ratio for the signalised junctions is fairly consistent at 3:1, close to the national average[xxxii], but for the roundabout it is much higher, nearer 7:1. A possible inference is that some females are averse to using the roundabout as they consider it unsafe.

Overall Road Use Analysis

The table below shows the road-use[xxxiii] analysis across all three junctions. It is striking that barely a quarter of cyclists, overall, use the junction in the way the design of the junction implicitly intends. The proportion on-road, for each junction, could be taken as a measure of the success of the design, considered as cycling infrastructure. Unsurprisingly, the signalised junctions "score" more highly than the roundabout. It should be added that training and experience play a part; experienced or trained cyclists know that the feeling of safety engendered by riding off-road can be illusory, and that it is usually safer to ride (correctly) on-road[2].

(xxviii) Noted during observations, but not counted

(xxix) Between the University and the Groody Valley student village – term-time only

(xxx) 285 of 321

(xxxi) Although the cycle traffic is naturally fairly heavily weighted towards the University in the morning and away from it in the afternoon and evening

(xxxii) 2011 census gives 2.7:1 nationally, lower in Dublin; note also that this data under-represents cycling generally, as travel is classified according to the main travel mode only, thus excluding cyclists who cycle part of the time or for part of the journey, and further, considers only commuting, to work / college

(xxxiii) Recall that to be classed as on-road, the whole junction has to be negotiated on-road, as vehicular traffic

Gender	Male	Female	Female %	**Totals**
Groody	279	42	13%	**321**
UL West morning	88	30	25%	**118**
UL West evening	73	24	25%	**97**
UL East	113	40	26%	**153**
Totals	**553**	**136**	**20%**	**689**

On / Off road	On-road	Off-road	On-road %	**Totals**
Groody	36	285	11%	**321**
UL West morning	30	88	25%	**118**
UL West evening	30	67	31%	**97**
UL East	83	70	54%	**153**
Totals	**179**	**510**	**26%**	**689**

Overall Helmet Analysis

The overall proportion of cyclists using a helmet is 13%, but there is fairly wide variation in the figures for each junction[xxxiv].

Overall Conclusions

The data show that a significant majority of cyclists prefer to negotiate junctions using an off-road style i.e. similar to pedestrians; this remains the case even if segregation is offered.

It is noticeable that a smaller proportion of cyclists adopt an on-road style for the west junction (25% / 31%), than the east junction (54%[xxxv]), despite a similar junction layout, which may be because the east junction has a higher proportion of university staff cyclists[xxxvi], who are likely to be more experienced cyclists than students.

Three main conclusions are suggested: First, training and experience play a part, which suggests cycle training, particularly for younger cyclists, would a very good investment. Second, partial segregation at road junctions is not enough for most cyclists; in particular, although the access road to the University[xxxvii] has cycle lanes, the two entrance roads to the University do not, and are too narrow[xxxviii] for comfortable cycling; the footpaths are partial compensation for this lack, but are not adequate for use by both pedestrians and cyclists, particularly at higher traffic volumes. More generally, any infrastructural inventions for cyclists at junctions must be considered as a whole, to be successful; partial measures may be ineffective. Third, urban roundabouts, like the Groody, are a major inhibitor of cycle (and pedestrian) traffic, that pedestrian crossings only partially overcome; this study has shown that they are used by the vast majority of cyclists. However, at peak times, the resulting mixture of pedestrian and cycle traffic is probably not far from its safe[xxxix] operating volume.

Finally, the present paper has only been able to touch on the diverse and complex issues raised, but the conclusion that the majority of cyclists do not use junctions in a manner anticipated by designers suggests there is clearly a need for more research and intervention.

Acknowledgments

This paper grew out of a proposal originally made to Limerick Council / Smarter Travel in October 2012. An audit of more limited scope, for the Groody roundabout only, was then undertaken in March – April 2013. The present paper is an extension of this audit; the author would like to thank Limerick Council / Smarter Travel for part funding of this paper.

References

[1] Dr. E. Pasenen, The Risks of Cycling, Helsinki City Planning Department, ~2000

[2] John Franklin has compiled a useful list of references under the heading “Cycle path safety: A summary of research”; http://www.cyclecraft.co.uk/digest/research.html (July 2013)

[3] Around 3%: Limerick Smarter Travel, Stage Two Submission, Department of Transport, April 2010

(xxxiv) From 8% to 29%

(xxxv) West junction: morning & evening, east junction: morning only

(xxxvi) Based on local knowledge of the location of student villages and other housing estates, rather than direct observation

(xxxvii) Plassey Park Road

(xxxviii) 7m at the east junction, see note (xii), page 3, similar at the west junction

(xxxix) The behaviour of off-road cyclists has attracted a lot of negative attention, particularly in Dublin, where traffic volumes are higher